U.S. ENERGY POLICY—PART II

Y 4.R 31/3:104-60

U.S. Energy Policy-Part 2, Serial N...

HEARING

BEFORE THE

SUBCOMMITTEE ON ENERGY AND MINERAL RESOURCES

OF THE

COMMITTEE ON RESOURCES HOUSE OF REPRESENTATIVES

ONE HUNDRED FOURTH CONGRESS

SECOND SESSION

ON

THE CONTRIBUTION PUBLIC LANDS AND THE OUTER CONTINENTAL SHELF LANDS CAN MAKE TO THE NATION'S FUTURE OIL AND GAS RESERVES, AND THE LEVEL OF DEVELOPMENT THESE RESERVES CAN REASONABLY SUPPORT

MARCH 21, 1996—WASHINGTON, DC

Serial No. 104–60

Printed for the use of the Committee on Resources

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U.S. ENERGY POLICY

HOUSE OF REPRESENTATIVES, SUBCOMMITTEE ON ENERGY AND MINERAL RESOURCES, COMMITTEE ON RESOURCES
Washington, DC.

The Subcommittee met, pursuant to call, at 2:28, in room 1334, Longworth House Office Building, Washington, DC, Hon. Ken Calvert (Chairman of the Subcommittee) presiding.

STATEMENT OF HON. KEN CALVERT, A U.S. REPRESENTATIVE FROM CALIFORNIA, AND CHAIRMAN, SUBCOMMITTEE ON ENERGY AND MINERAL RESOURCES

Mr. CALVERT. The committee will come to order, please. I apologize for the delay. We expected a vote which did not occur, but nevertheless, we will start the hearing.

The subcommittee meets today for a second oversight hearing on energy and policy issues. We began this inquiry with a field hearing in Houston, Texas, just a few weeks ago to find out what several of our states are doing to revitalize our oil and gas sector.

Today, the subcommittee wishes to investigate the contribution public lands and the Outer Continental Shelf lands can make to the nation's future oil and gas reserves, and the level of development these reserves can reasonably support.

The United States has done little to encourage domestic production, and in many cases, Federal policies actually discouraged domestic exploration for gas and resources or production of reserves so discovered. In 1995, crude oil production averaged 6,520,000 barrels per day, the lowest production since 1954. Well completion rates and drilling rates for exploratory wells were both at post-World War II lows, indicating that our domestic production rate will likely continue its dramatic decline in the lower 48 and also in Alaska.

Yet, many scientists believe our nation's oil and gas resources are abundant. They predict as much oil and gas will be found and produced here in the future as has ever been produced domestically. Recent estimates are that we have domestic supplies of 204 billion barrels of oil; 1,295 billion cubic feet of natural gas, enough to sustain a sizable domestic gas industry for almost 50 years or for more than 50 years.

Declining domestic production is a major cause of our chronic trade deficit which is becoming increasingly worrisome. The U.S. now imports over 8 million barrels of oil per day, nearly 50 percent of our domestic consumption at a cost of approximately $1 billion a week.

At today's price, each additional 100,000 barrels per day that we can produce domestically to replace imports will decrease the trade deficit by nearly $900 million annually.

At current volumes, imported oil denies many American citizens good economic opportunities. About 20 jobs are created in all sectors of the economy for each $1 million invested in the domestic oil and gas industry. Each and every barrel lost due to the domestic production decline is replaced by an imported barrel of oil.

As important as alternative energy sources are, oil and gas will continue to be the major source of energy for the remainder of this as well as the next generation of Americans.

The domestic oil industry has lost more than 500,000 jobs in the last decade. That is more than the auto, steel, and textile industries combined. Federal policies should do more to encourage domestic production of competitive reserves and provide well-paying jobs for Americans to produce a commodity which is vital to our society.

Today, the subcommittee will hear from witnesses representing the Bureau of Land Management and the Department of Energy who will testify about their agency's role in oil and gas initiatives for the coming fiscal year.

Witnesses from the U.S. Geological Survey and the Minerals Management Service will testify about estimates of undiscovered oil and gas resources for the U.S. on-shore and Outer Continental Shelf respectively, and an Energy Information Administration [DOE] witness will testify about demand projections.

Lastly, nongovernmental witnesses will testify on their group's views of the validity of governmental forecasts and a need for policy revisions, if any.

Because of the delay, and again, I apologize, we gave the Federal witnesses ten minutes to give their testimony. If any way possible you could shorten that, that would certainly make the committee happy, I am sure, but we would like to without any further delay introduce Mr. Kyle Simpson, the Associate Deputy Secretary for Energy Programs; and Dr. Michael Dombeck, the Acting Director of the Bureau of Land Management. First, I would like to introduce Mr. Kyle Simpson. You may begin your testimony. Thank you, Mr. Simpson.

STATEMENT OF KYLE SIMPSON, ASSOCIATE DEPUTY SECRETARY FOR ENERGY PROGRAMS

Mr. SIMPSON. Thank you, Mr. Chairman. I will mark through about 15 pages here and see if we can trim this thing down some, but I would ask that you submit the full statement into the record.

Mr. CALVERT. Without objection.

Mr. SIMPSON. I think you have set a pretty good stage on the level of oil production and imports. I would also point out that world oil demand is going to increase another 20 million barrels per day by the year 2010 from the 69 million barrels that we have today, and many more countries, developing nations, are going to be competing for that oil resource.

If China and India's per capita energy consumption rose to that of South Korea and their population increased at current projected

rates, those two countries alone would need a total of 119 million barrels of oil a day.

The future demand for oil around the world will continue to rise dramatically, meaning that we need to develop resources in this country as efficiently as we can and deplete them as efficiently as we can.

You commented that domestic production is declining. The Energy Information Administration's latest annual energy outlook indicates that oil production continues to decline, but anticipates because of technological advances that are being made and are anticipated to be made in the future that will continue to drive production costs down, that the trend downward in oil production may actually reverse in the middle of the first decade of the next century.

Natural gas production has been increasing for the last decade and steadily continues to increase as consumption steadily continues to increase.

The Administration's energy policies are based on decades of experience in dealing with energy issues. We learned that price and allocation controls did not work for us in the 1970's any better than they worked for the old Soviet Union, and we learned that big ticket large project development often is not the best approach toward building a balanced portfolio of energy investments. Most importantly, we learned that lurching from policy to policy in the wake of successive crises, trying to change overnight the way people live, work, travel and invest is expensive and counterproductive. Instead, a steady, sensible policy approach seeking long-term, cost-effective results and relying on markets is the one that we are taking.

I want to briefly review a number of the accomplishments of the last three years. We have aligned the Department of Energy's research and development programs with the concerns of industry. We used what we learned from the domestic natural gas and oil initiative to help us learn what industry needed and are using that to help spur greater oil and gas production.

After a 23-year period, the ban on exporting oil from Alaska has been lifted, and that will mean more than 25,000 new jobs for American workers, particularly in Alaska and California. To maintain a healthy, robust domestic gas and oil industry, new deepwater royalty provisions will unlock an estimated 15 billion barrels of oil equivalent in the Gulf of Mexico.

We are delivering on a pledge to help the industry increase the supply and utilization of domestic natural gas. From 1993 to 1995, our gas production is up five percent; our consumption is up six percent. The natural gas rig count is up 30 rigs per month over that same period and the Gulf of Mexico rig count today is at its highest level since 1990.

This Administration's commitment to free trade has helped to diversify our oil supplies which is another important goal that we have been trying to achieve. Imports from the Persian Gulf are down by 13 percent, and in August of 1995, Venezuela supplanted Saudi Arabia as the largest supplier of oil to the United States.

The Administration will propose new regulatory compliance regimes that link increased flexibility with greater accountability,

and will achieve better environmental protection at lower cost to the energy industry, another important element.

The Interior Department has issued new rules that cut the royalty rates for heavy oil produced on Federal lands by as much as 12 percent to increase recoverable reserves of heavy oil in California by 72 percent. The Department of Energy has provided greater access to the world-class technological research capabilities of our national laboratories.

Partnerships are formed with the independent producers, universities, major producers, and the service companies, and these industry-driven, cost-shared projects are designed to drive down exploration and production costs.

We have also moved to get the government out of the business of producing oil and gas by working with the Congress to get passed a bill to allow us to sell the Elk Hills Naval Petroleum Reserve and get the government out of competition with industry in the oil business.

The Administration has granted most of the royalty relief requested on stripper oil wells, developed royalty relief for heavy oil, is studying royalty relief for marginal natural gas wells on Federal on-shore land, and has successfully completed a negotiated rulemaking that will reform calculation of payments due on royalties for natural gas to make them more predictable.

We have also had some disappointments. The inappropriate financial responsibility amounts in the Oil Pollution Act of 1990 have not yet been successfully resolved despite the best efforts of the Administration and the National Petroleum Council. We hope that the Congress can work out its differences and get that measure passed. This will help reduce cost to the industry.

Budget cuts to successful programs are also disappointing. The benefits of these programs far outweigh their costs. I am speaking of the research and development programs in large part carried out by the Department of Energy that will help to build a stronger domestic industry and move to a cleaner environment and to create a safer, more secure energy future.

I want to talk just a minute about some of these research and development programs that are important to ensure that we have the availability of reliable sources of affordable energy and the efficient utilization of energy. We believe that these two elements will be critical for the foreseeable future. That is why we have an extensive number of sharply focused, energy R&D initiatives and programs that enable us to sensibly diversify our portfolio of energy resources, improve our environment, and increase the nation's ability to respond more deftly to changing circumstances that may include energy price shocks caused by sudden supply disruptions in the global market.

Our R&D programs designed in concert with industry to supplement and improve the productivity of their R&D investments are a part of the nation's portfolio for the future. The technical advances that flow from our collaborative efforts create a stream of future benefits that enhance the energy sector's long-term economic growth and productivity.

The health of the natural gas and oil industry depends upon the price of oil and gas and the cost of its production and delivery.

While our government has no control over world oil or domestic gas prices, and desires none, we can and do play an important role by helping U.S. producers lower their production costs by developing and deploying advanced technology as well as by reducing costly and duplicative regulatory requirements.

Since 1992, this Administration has doubled its R&D for advanced technology investments with America's gas and oil industry to help lower their exploration and production costs while expanding our nation's resource base. Industry exploration and development costs since the 1980's have declined 75 percent, to $4.53 a barrel from $21.50 for a barrel-of-oil equivalent. The costs are down 37 percent from 1994 to 1995 alone.

Advanced technology oil research and development programs continue to expand resource recovery by 4 billion to 7 billion barrels and lift production by 600,000 to 900,000 barrels a day by the year 2010. Our natural gas R&D programs will help lower production costs by $290 million per year and contribute by adding nearly 2 trillion cubic feet of new gas production by the year 2010.

Using advanced technology, U.S. operators in 1994 successfully discovered oil and gas for 38 percent of all exploratory wells drilled. That is up from 29 percent in 1981.

Vastar Resources, Inc., says its exploratory wells now hit paydirt 60 percent of the time as a result of new technologies like 3D seismic. Their chief executive officer says he thinks there are still some creative ways for cost cutting to continue.

As recently as three years ago, Enron Oil & Gas used 3D seismic on only 15 percent of its on-shore exploration projects. Today, they base 60 percent of their on-shore drilling on 3D; in five years, that will increase to 75 percent. According to the president of their North American operation, 3D seismic is allowing them to drill fewer wells and find more gas per well drilled.

Dan Yergin, the president of Cambridge Energy Research Associates has said that one of the major consequences of this new technology is a leveling of the playing field as a result of which, instead of having the seven sisters of yesteryear, you will have perhaps 7,000 sisters tomorrow, and that, of course, will completely transform the competitive dynamics of the industry. Technology will be the difference for companies that succeed in oil and gas development in the future, and it is the equalizer between the major and the independent companies.

I have got just four quick charts I wanted to put up to show where some of this success has occurred. Natural gas reserve replacements are up over the last three years. It is a steady trend, and we are seeing most of it come from the offshore.

Finding costs of U.S. companies are now competitive with the average finding costs around the world, and that is through technology development and deployment.

The amount of natural gas that is found per well completion, while up and down, has a steady line going up through the out years, and lastly, and this is very important and it is why we have focused so much of our effort in working with industry and working particularly with the independent industry, investment in domestic exploration and production is up and almost half of it is now done

by independent companies, so we have been working very hard to move with them.

We will continue these efforts, and we look forward to working with the Congress to move forward to make other improvements. Thank you, Mr. Chairman.

[Statement of Kyle Simpson may be found at end of hearing.]

Mr. CALVERT. Mr. Dombeck, the Acting Director of the Bureau of Land Management.

STATEMENT OF MICHAEL DOMBECK, ACTING DIRECTOR OF THE BUREAU OF LAND MANAGEMENT

Mr. DOMBECK. Thank you, Mr. Chairman, and good afternoon, and good afternoon, Mr. Thornberry.

I appreciate the opportunity to be here and I, too, will give an abbreviated statement and ask that my entire statement be submitted for the record.

Over the past three years, we have made a number of significant accomplishments and have many project initiatives in progress which reflect our commitment to a collaborative effort when it comes to making decisions which affect the use of public lands.

First, I would like to thank the Department of Energy for their technical support and the partnership over the last couple of years. Together, the Bureau of Land Management and DOE have a positive working relationship and we believe we have improved the quality of service to all our customers.

At the end of 1995, more than 51,000 leases existed on Federal lands covering about 37 million acres. About 19,000 leases were in the producing status. Now, there are more than 63,000 producing wells on public lands. That is up 30 percent since 1985, and during that same period, natural gas production has increased by over 60 percent.

The oil and gas program generates receipts from filing fees, bonuses, rentals, royalty payments. In 1997, we expect such royalties to exceed $500 million. Except for the filing fees, these receipts are shared with the states and are a very important source of economic revenues for our western states.

Our leasing program will continue to be focused on those areas where the prospect for discovery is highest. We will be encouraging industry to nominate parcels while at the same time reducing the number of parcels which BLM offers on its own initiative. We want to be more efficient.

The 1997 proposal stresses continuity of services and additional progress toward implementing streamlined processes and cost savings. As you know, BLM has conducted a performance review that has evaluated the Bureau's oil and gas operations, regulations and policies, and identified opportunities for the way we do business. We have recommended numerous changes.

We are proud of the progress with heavy oil. BLM's new rule published on February 8 of this year establishes conditions under which operators of properties that produce heavy oil, crude oil with a specific gravity less than 20 degrees, can obtain reduction in the royalty rate. As a result of this action, more wells will remain in production even if prices are low.

We are improving the process for dealing with applications to drill. BLM is evaluating the problems that make it difficult to meet the goal of timely approval of all applications. In particular, although the vast majority of APDs submitted to the BLM are reviewed and an operator receives a timely decision; in some instances, the application process is still taking too long.

To address these concerns, BLM has formed an interagency task force to identify obstacles and to develop internal procedures that will help expedite the process. The APD task force is scheduled to complete its work by early June of this year.

We are continuing to streamline certain duplicative processes associated with our program.

Natural gas is the cornerstone of the Clinton Administration's domestic energy policy. On February 7, the Secretary of Interior established the Green River Basin Advisory Committee to advise him on all aspects of BLM's activities that affect or are influenced by our natural gas and oil program in the greater Green River Basin. The committee will provide a means for addressing certain concerns of both industry and the environmental community while facilitating environmentally responsible development of oil and gas resources in that region.

I want to point out that this committee is not a decisionmaking body nor another layer of bureaucracy. It has no authority to impose new regulations. Its function is to advise the Department of Interior and the Bureau of Land Management on how to best manage this world-class resource.

Mr. Chairman, I welcome any questions that you have, and I would also like to introduce Mr. Howard Tipton, assistant director of resource use and protection, that understands the technical aspects of our program.

[Statement of Michael Dombeck may be found at end of hearing.]

Mr. CALVERT. Thank you, Mr. Dombeck. I first would like to ask a couple questions of Mr. Simpson.

In the first part of your testimony, you mentioned the increased demand for oil and gas products in Asia and the pressure that that is going to have on supply worldwide, and as we see a relatively historic low in the price of oil, do you think that in the future, that if this demand continues to rise, that we could have shortages of oil or increases in oil in the relatively near future based on that?

Mr. SIMPSON. Not based on just the market acting by itself. From the Energy Information Administration and the International Energy Administration, there appear to be ample reserves in the world to meet the rising demand. It will require a significant amount of investment in exploration and production and infrastructure around the world, but the fact that market demand will be rising that much does not indicate that there will be shortages.

There are, however, circumstances under which price and supply disruptions could occur. There have been a number of those in the last 50 years, at least seven in the last 50 years. Each of those has focused around some action occurring in and around the Persian Gulf, and those types of disruptions can cause rather dramatic price impacts, many of them short lived, but almost always associated with a recession that follows on or near that occurrence.

Mr. CALVERT. And that is one of the reasons that we are having these hearings. As you know, over 50 percent of the oil that we use domestically today we are importing and production looks like it is continuing to fall. The last major area in which—what do they call that, the elephants of the world, is possibly in Alaska, but we don't know for sure.

So we are trying to increase our domestic production, and I appreciate your statement about our Royalty Fairness Bill in the regulatory relief section of your testimony.

Believe me, this is the strongest statement I have heard yet from the Administration about what we have accomplished together in that negotiation. I certainly believe its enactment and implementation would help solve problems at the downstream and in the Federal oil and gas leasing business, and thereby would indirectly foster more participation by oil companies, particularly the independents, in being willing to lease from the Federal Government.

Would you like to comment further on the royalty fairness or the Administration's position on that bill?

Mr. SIMPSON. The Administration has not developed a formal position on that. We have been working hard with the members of your committee and your staffs to try to work through the differences that occur on the bill, and we would look forward to continuing to do that, to try to work out those differences.

Mr. CALVERT. We are hoping that we can do that soon and we can continue to increase production here domestically and lower costs for the treasury. It seems like it is a win-win situation.

Mr. Dombeck, I am well aware of the BLM rule finalized in February allowing for royalty reduction on heavy crude with a gravity less than 20 degrees and the benefit to California producers. In the last session, the subcommittee pursued this issue and held legislative hearing at a markup of that legislation.

Other regions of the country, primarily Wyoming, produce heavy crude in the range of 20 to 25 degrees. What other options and economic factors is BLM considering to help keep marginal properties such as those in Wyoming producing during periods of low oil prices, such as we are experiencing today?

Mr. DOMBECK. The specific answer to the question on heavy crude and the 20- vs. 25-degree oil, I think, any operator has the option to apply for a royalty rate reduction, and we can deal with that in that manner.

Some of the other efficiency options that we are looking for, I think some of the accomplishments of the performance review that we are proud of, it not only makes things simpler for the BLM but also makes things simpler for the operator.

We have gone through this process with input from states, tribes, input from the industry, and one of the cornerstones of my efforts at BLM are to go ahead and simplify the system, avoid duplication of effort, move away from serial processes toward parallel processes so we can give more timely service to customers.

Mr. CALVERT. Thank you. Mr. Thornberry?

Mr. THORNBERRY. Thank you, Mr. Chairman, and let me start by expressing my appreciation to you yet again for this series of hearings. This is an important topic and yet, it often gets little to no

attention, I am afraid, by the Congress and the Administration as well as the public in general.

I think we are about exactly five years since the Persian Gulf War and yet we are more energy-dependent than we have ever been. Correct me if I am wrong, Mr. Simpson, but I believe something like 20 percent of our oil comes from the Persian Gulf region still today, and we are vulnerable to all sorts of disruptions because our domestic production is declining and continues to decline.

Mr. Simpson, I apologize. I walked in when you were in the process of your statement, but did I understand you to say that your forecasts indicate that domestic oil production will start to increase again sometime shortly after the turn of the century?

Mr. SIMPSON. In the middle of the first decade. That is right, Congressman.

Mr. THORNBERRY. And what price do you assume for oil for that to occur? It has got to be dependent upon price, doesn't it?

Mr. SIMPSON. Well, we assume that prices will gradually rise to $24 a barrel by the year 2010. Historically, the price of oil today, given the fact that it closed at $23.06 on the NYNEX yesterday, is an aberration.

The prices that we are seeing today are roughly similar to the prices that we have seen historically since oil became a major fuel at the beginning of the century, and we don't see any real change in that price.

What we expect is that technology and the driving down of the cost of production, for example, the new three-dimensional and four-dimensional seismic, are going to lower the cost of production such that we will be able to increase production in the U.S. at prices roughly equivalent to today's.

Mr. THORNBERRY. The concern that I have is that it obviously takes money to acquire new technology, and in the meantime, we have a number of independents who are not able to even make it to when the new technology is available much less have the capital in order to acquire this new technology.

In the meantime, what is happening is that several, and you can tell me the number, thousands of wells are being shut in every year of low producing wells, and we are losing that capability. Is there any program or effort by the Administration to prevent these low-producing wells from being shut in and to try to keep them on line so that that source of domestic production is not lost forever?

Mr. SIMPSON. There are a number of things. I think we saw when the price of oil went down two winters ago to $12, $13 a barrel, the impact on the marginal wells was critical. At that time, we spent a great deal of time trying to find an incentive that would be revenue-neutral, that would affect those wells, and we found that that was a very difficult thing to do.

If you had used a broad brush, you would end up with a tax code about like this just to try to deal with it, and that alone would put some of the independent companies out of business just to try and keep up with that. So we have turned and we have looked for some other ways to do it.

One of them is what Mr. Dombeck has pointed out, on Federal lands, when wells get into a marginal production category, we can lower the royalties on them to lower those costs.

The other is to try to aggressively move that technology into the independent producers' hands. We have set up in conjunction with the producers the Petroleum Technology Transfer Council out of the Department and divided the country into ten different regions so that we are close to the areas where the independent producers are.

Many of our research and development activities including the advanced computational forum which last year did not receive any funding in the Interior appropriations bill despite the fact that about 100 companies applied and formed various consortia to work with our national laboratories to develop these new technologies using our high speed computers.

We have asked in our budget request for funding for that program this year, and we are really trying to work with the independents to get this technology closer to them, faster to them, and we believe that is beginning to have some effect.

Mr. DOMBECK. If I may, I would like to add that we have issued a **Federal Register** notice asking for comment on things that we can do as far as potential royalty reduction on marginal gas to achieve the same kinds of ends that we worked toward on the heavy oil royalty reduction.

Mr. THORNBERRY. Let me ask finally, I think there is a comment in your statement that hits the nail on the head.

It basically says that while we can't do much to control the price, we can certainly have some impact on the cost of production, and let me just quickly tick off three things, and you can tell me where the Administration stands on them.

Number one, on regulatory reform particularly affecting oil and gas folks, including cost benefit analysis and so forth, where do you stand on that?

Number two, amending the Oil Pollution Act of 1990, there is some concern that independents may have to leave any OCS activity unless there is reform there.

Thirdly, there is an effort to have a limited antitrust exemption to encourage natural gas marketing cooperatives.

Where do you all stand on that?

Mr. SIMPSON. On the reg reform, it is something that we are dealing with in an administrative way, in the Administration on a daily basis and working to try to get duplicative regulations out of each other's way, so there is not duplicative work, to make it easier to deal with the government, to make things more on a voluntary basis rather than a mandatory basis, and those are constant activities and we are working hard on them.

On OPA '90, as I have expressed, we are strongly supportive of reducing the financial responsibility requirements in OPA '90 and hope that that bill can be worked through Congress this year.

On the third thing, that is a problem. The bill that was introduced is a little far-reaching. We have been working with the Justice Department to try to find a way to accommodate the interest of the independents.

There is an aberration in the market that is limiting the ability of the small independents to get to the marketplace, and we want to try to find a way to work on that. We have been meeting with all aspects of the industry and the Justice Department to try to

work out something that will work, and I would be glad to visit with you later about that.

Mr. THORNBERRY. Thank you, Mr. Chairman.

Mr. CALVERT. Thank you, Mr. Thornberry. Before I turn it over to Mr. Abercrombie for questioning, I have just one comment.

In your testimony to Mr. Thornberry, you indicated you thought that the price would be relatively flat based on today's dollar through the first decade of the next century.

I read an article not too long ago—that is dangerous—in "Fortune" magazine about some of the wealthiest men in the world are investing in oil right now. The primary reason was what we talked about earlier, the worldwide demand for petroleum product is rising, and the supply is dwindling in their mind's eye, especially here in the lower 48 because production is obviously continuing to decline; marginal wells are continuing to go off-line.

Obviously, Alaskan production has continued to decline from a height of 2 million barrels a day now to about 1,300,000 barrels a day, unless ANWR is opened up and that is questionable at the moment, then production will continue to decline in Alaska, and if production doesn't rise and supply is static and demand is continuing to increase, don't you believe that that might increase prices?

Mr. SIMPSON. There is no indication that supply is static. I don't believe that the people that are investing in this believe so much that they are going to make a big hit on rapidly rising prices. There may be some aberrations as there have been throughout history of rapidly rising prices, but what seems to be clear is that there will be enough demand to sustain investment that will give a good return to supply oil to those markets.

The resource bases throughout the world that are being discovered and have not been fully depleted can meet much of that demand. The reserve base in the Persian Gulf alone can keep producing at its current rate for 90 years, and the Saudis are bringing on an additional 2 million barrels of capacity that aren't even needed at this point to meet the current demand.

We are seeing that places like Venezuela, by the year 2000, will be producing twice the amount of oil that they can produce today. They will go up to almost 6 million barrels a day. Saudi Arabia can increase their production substantially. The Caspian Basin has tremendous reserves in it, and there are several companies that are now under embargoes, that if they came back on line, have the capacity to supply some 5 million to 7 million barrels of oil a day.

So when you add those numbers up, you find that there is in fact the capacity to meet the demand without a substantially rising price, particularly when technology comes down, and that is what our challenge is in this country, to get those costs of production down so that we can compete.

Mr. CALVERT. I hope you are right, because as you know, rising energy prices can cause all kinds of havoc in the economy, and if the world's wealthiest men are wrong, we will see. They have indicated they are investing because they believe that the price will go up sharply.

I will leave the next question to Mr. Abercrombie from Hawaii.

Mr. ABERCROMBIE. Thank you very much, Mr. Chairman. May I have your permission—I beg your pardon. I was unavoidably de-

tained elsewhere, and may I have your permission to enter a statement into the record?

Mr. CALVERT. Without objection.

Mr. ABERCROMBIE. Thank you very much.

Mr. CALVERT. So ordered.

[Statement of Hon. Neil Abercrombie follows:]

STATEMENT OF HON. NEIL ABERCROMBIE, A U.S. REPRESENTATIVE FROM HAWAII

The purpose of today's oversight hearing is to look at the overall health of the domestic oil and gas industry and determine whether or not Federal policies related to the public lands, including the Outer Continental Shelf, are helping or hindering domestic production.

There is little doubt that we must efficiently use what is left of our domestic oil and natural gas resources if we are to meet our energy needs today and into the future. While the deepwater of the Gulf of Mexico is clearly a new and exciting frontier, we are certainly beyond what some called our "peak" years of production.

Since taking office in 1993, the Clinton Administration has developed a strong national energy policy—made up of various programs and policies which appear to be having a beneficial effect on domestic production. While there may be Federal regulatory policies still in need of adjustment, the Clinton Administration has been more than fair in responding to the many needs and requests of the domestic petroleum industry.

Their record is quite impressive. Deepwater royalty relief, lifting the ban of export of Alaskan oil, royalty relief for producers of heavy crude oil, and the proposed change in OCS bidding systems are but a few of the initiatives taken over the past 3 years to aid the domestic oil and gas industry.

On a related issue, I am hopeful that Rep. Calvert and I will be able to come to agreement on the issue of royalty fairness before the bill comes up in full Committee next week. And, if that bill is enacted, then that will be another initiative to benefit the oil and gas industry.

Perhaps alternative and renewable energy methods will become more prevalent in the next few decades, but I agree that it seems more likely that we will continue to rely primarily on oil and natural gas. On a personal note, I have been active in seeking assistance from the Executive Branch for mass transit in Hawaii—not the jurisdiction of this Subcommittee, but, we need to bear in mind the many facets of a national energy policy, such as public transportation and alternative energy options when we focus in on one aspect such as oil and gas.

The Federal Government must act as responsible stewards of the public's resources. To paraphrase some of my Republican colleagues, we should ensure that the Federal programs that control development of these resources are run more like businesses—and not like corporate welfare.

Mr. ABERCROMBIE. Mr. Simpson, as long as we are getting into the level of prognostication, I would like to engage in it just for a moment with you, and trust that you will believe me when I read some things to you, that I am in fact quoting correctly and so on.

The reason I am going to do this, I want to say in advance is not to try to trick you or Dr. Dombeck or anybody else here, but to say that there are honest differences of opinion as to what may or may not be happening at the moment, and that my observation is, as someone who is trying to get on this learning curve with what our responsibilities are, that we need to look at the long-term and come to conclusions as to what we should do, but we don't want to be mesmerized by present conflict of opinion.

I have an article from "Forbes" magazine, and I thought that would be good to have, because my understanding is that Mr. Forbes edits every word that goes into his magazine, and as a result, we can count on it that this is what he thinks, or this is what he approves of.

This is by Steven H. Hankey, who is a professor of applied economics. What he applies the economics to, I am not sure, but in this instance, it is oil at Johns Hopkins.

This is an article which says oil prices are going down, and that oil companies are betting that they are going down for the moment, and this is on a short-term basis.

I won't go into the whole thing, but there was a quote from Samuel Johnson, I thought, that would perhaps add to the general tone of our discussion. Samuel Johnson described that mood. The mood that he is talking about is that if you own oil stocks or deal with oil in any way, get ready for a price drop. It is hard for most people to grasp the inevitability of lower oil prices, and that is because they have been fed an unending stream of doomsday fiction about the scarcity of oil. Samuel Johnson described the mood very well, "The mind that has feasted on the luxurious wonders of fiction has no taste for the incipity of truth."

My colleague says it sounds like Mr. Forbes, but in fact, because I didn't want to take the blame for that, in fact, it was Samuel Johnson, but the point is that this article goes on to establish that there is a picture of a gentleman holding a pipe in his mouth, which always adds to authority, I think, and I am not necessarily saying that his point is absolute, but these things tend to get stated in absolutes, and I could go on. I have other articles here talking about oil industry sprouts promise after dry spell, rigged for recovery in the "Dallas Morning News," etc., etc., reserves debate from the "Oil & Gas Journal."

This is Paul Appleby, senior economist for British Petroleum Company. Appleby, sounding the optimist's view, said that reserve strength and new discoveries enable total reserves to grow faster than production. "By this measure, rather than running out of oil, we seem to be running into it. The perception of oil as a dwindling resource seems to be a hangover from the late 1970's."

I would like to have for the record your observations or that of Dr. Dombeck with respect to this whipsawing that happens to ladies and gentlemen who serve on this committee who are not necessarily involved in oil production and searching every single day, but nonetheless, have to make decisions based on what presumably is expert advice including yours. So I would like you to comment on this question of the direction we should possibly be taking when we are faced with this kind of contradictory expert advice.

Mr. DOMBECK. You raised with that one of the interesting elements, and I am glad you do raise it, because there is more to energy policy than just energy supply. The other elements of our approach are economic security, national security, environmental responsibility, and the choices that one makes and that this Administration has made that improvements in our environment are a key element of our overall energy policy are found in other places in our work. That is why we are working for a new generation of vehicles that will get 80 miles to the gallon as opposed to what we have today.

That is why we are working on technologies that will reduce pollution. We are working on alternative types of fuel technologies. We want to move into things like biomass and improving the use of

solar and wind, because the world may be awash in oil, but it is not the cleanest form of energy we can use.

If we can find ways to drive down the cost so that these other fuels are economically competitive with oil, then we have the ability to make choices at that point for reasons that include the environment.

If we were able to switch to other types of fuel, we would not be subject to the trade deficits that we are subject to now, because we have to purchase oil, and we would not be contributing wealth into some politically unstable regions of the world.

All of those things would improve our national security and our environmental quality and give us a more stable energy environment in which to live. So whether one believes that prices—if one looks at the historical pattern of oil prices and sees that they are basically flat since the year 1910 with about six or seven different aberrations through the course of history; if one believes that technology and free markets and open borders and free trade are allowing us to run into oil and run into so much oil that it will not be a problem in the future, and therefore, prices are going to go down, or if one believes that prices are going to go up dramatically, because in fact we may face a situation where demand will rise faster than supply.

If you put together an energy policy that takes all of the other things into account, then you can take on each one of those scenarios, and that is what we are trying to do and trying to do it in a way that doesn't cause us to have to react to crises, but to have a steady vision of where we want to be in the future and take on each one of these different scenarios.

Mr. ABERCROMBIE. Thank you. Dr. Dombeck, I am a little bit over time. If you could comment, though, I would be appreciative.

Mr. DOMBECK. I am not sure I can add to that from the standpoint of the commentary, but I think what I can do from a standpoint of what BLM can contribute to this, our objective is to provide predictability in things like access, timeframes the industry has to work in.

I mentioned earlier in my opening statement some of the points about access. In fact, in Wyoming, we are proud of the memorandum of agreement that we have signed with the state historic preservation officer to streamline the clearance process to provide access for industry, and there are a variety of examples like that, I think, where we in the agencies can work more efficiently and streamline our processes, and from our standpoint, as a major contribution to the effectiveness of the industry and the viability of the industry in the United States.

Mr. ABERCROMBIE. I don't want to abuse the Chairman's indulgence of me, but I assume, Mr. Simpson, inasmuch as I didn't see you wagging your head vigorously sideways that you are in essential agrement with Dr. Dombeck.

Mr. SIMPSON. Yes.

Mr. ABERCROMBIE. Thank you. Thank you, Mr. Chairman.

Mr. CALVERT. Thank you. I just—one comment. Oil is a commodity like any other commodity. It is based on market, but one thing about oil that is somewhat different is it is such a capital-intensive in order to extract that product.

If Mr. Forbes is right—he wasn't right about some things, but say he was right about that, and we had a short-term plunge in oil prices, and I suspect that is what that is indicating, a short-term decline in prices, and additional marginal wells go off-line; it is not economical any longer to produce oil, especially stripper wells in Texas and Oklahoma and other areas throughout the lower 48, heavy crude production in the central part of California, because it is cheaper to just import oil from the Persian Gulf. It is easier, less hassle, just bring it in.

So our imports continue to rise. Doesn't that cause a whole new set of problems? If industry would like to have, I suspect, a constant price, in order for them to maintain that price, they need to maintain production, and that is what these hearings are about, to maintain a viable domestic industry, so I just wanted to make that comment.

Mrs. Cubin is here and joined us, and another large producer of oil is the state of Wyoming.

Mrs. CUBIN. Thank you, Mr. Chairman. I can understand that more than just the quantities of oil, for example, need to be taken into consideration when you are planning an energy policy, and you mentioned that this Administration is more interested, or one of the key things in the equation is the environment, and it is obvious from the policies that that is true.

But there is one thing that I wonder if the Administration has thought of, and that is, importing all of this oil has polluted the world more than drilling for all the oil in the United States. Look at the oil spills that we have had in the oceans.

I think that is a very important part. In Alaska, the *Valdez* and so on. That is the environment, too, and not only is it cleaner to have domestic oil, but I would think in terms of our national security, that we ought to have a viable—and I know that is the goal, but maybe we have a different definition of what a viable industry is.

Right now, it is tragic that 175,000 folks, their jobs have been affected by the strike with GM. Well, 500,000 jobs were lost in the oil and gas industry, and nobody noticed.

I think that economics and jobs ought to also be a part of that equation, and I do realize and I am very appreciative for the royalty exemption on heavy oil.

I wondered—Dr. Dombeck, maybe you would know, tell me what the process for applying for that exemption is and has anybody used it yet?

Mr. DOMBECK. I am not familiar with the process itself. We would be happy to provide you with that information and it may be that Mr. Tipton knows the process, and if not, we will provide that for you for the record.

Mrs. CUBIN. Thank you. I would appreciate that very much, and I had to step out to see some constituents while some questioning was going on, and that has to do with the 20 to 25 degrees that Wyoming and other states mostly have, and has the Administration changed its position on allowing or even looking at allowing 20- to 25-degree oil to qualify for that exemption?

Mr. DOMBECK. Our rule was published, I believe, in February to allow for a royalty reduction that was a cutoff point of 20-degree

oil, but however, as you—and typically, that is the area that industry recognizes as the cutoff point, as well as the IRS, but I think the key point is that industry is free to apply for reduction at 25-degree oil and make the case, and we will give that very careful consideration.

Mrs. CUBIN. So it would be fair to say it would be a case-by-case——

Mr. DOMBECK. That is correct.

Mrs. CUBIN. [continuing]—thing at that weight?

Mr. DOMBECK. Yes.

Mrs. CUBIN. Thank you. Now, to the Green River Advisory Committee for just a second.

It is my understanding that they have made steps to expedite their actions. I believe they will be meeting weekly instead of monthly, and they will be coming up with a set of recommendations to the Secretary on how to facilitate responsible development of that area down there in southwest Wyoming.

If the committee does present those recommendations to the Secretary within six months as they are planning to do, what is your understanding of what will happen after those six months?

Mr. DOMBECK. Not knowing what the recommendations will be, it is very difficult for me to predict, but what I can assure you is that our objective in this is to make sure we take all aspects of all the issues into consideration with all the stakeholders at the table and avoid any kind of a situation where we enter into legal gridlock and things like we have in other areas.

What I can assure you is that they will be given very, very careful consideration.

Mrs. CUBIN. Will the committee be disbanded after that time, do you know?

Mr. DOMBECK. As of now, the committee sunsets in one year.

Mrs. CUBIN. Would you know if there are any plans to recharter the committee?

Mr. DOMBECK. Not that I am aware of at this time.

Mrs. CUBIN. The reason I was asking is just for oversight or implementation or coordination or something. I could see a benefit, maybe.

Mr. DOMBECK. I also think that we would consider that very carefully at the time.

Mrs. CUBIN. I don't think I have any other questions right now. Thank you. Thank you very much.

Mr. CALVERT. Thank you. I want to thank this panel. We are going to be sending some follow-up questions for you in case there are any more questions that any of us would like to get written replies to.

Mr. ABERCROMBIE. May I——

Mr. CALVERT. Yes.

Mr. ABERCROMBIE. [continuing]—just follow up very quickly?

Mr. Simpson, you don't have to give a detailed answer now, but as one of those questions, can you tell me what the status of the Deepstar project or proposal is, if you are familiar with it?

I am interested in the context of whether oil prices are going up or down. Nonetheless, I think we should have the government participate where it can within the jurisdiction of the United States

to be able to discover and to utilize deposits where it is a useful endeavor.

I was intrigued with the possibility of a private-public partnership in this Deepstar program, although I have to admit that it was going through the advanced technology program which is in the Commerce Department which some people want to get rid of, but I am hoping that at least the function of that program, the advanced technology program, would continue, and it was taking up this Deepstar—for those that might not be totally familiar with it, it is the deep-water oil production research activity, and I thought it looked promising.

That was in 1995 that I first became aware of it, and I am not sure of the status.

Mr. SIMPSON. The funding levels for it have been substantially reduced in large part because the funding that we had for the advanced computational technology initiative was zeroed out in the Interior appropriations bill in 1996.

We are continuing to work with the consortium in trying to get some funding. We will try to get some funding for the project, because it was producing some promising results, and I will get you a more detailed answer, but it is one that we are very much interested in. The industry is very much interested in us moving forward on it.

Mr. ABERCROMBIE. Is Mr. Hochheiser still connected with that from the office of oil and gas exploration and production?

Mr. SIMPSON. Yes. Yes.

Mr. ABERCROMBIE. So he could bring—Mr. Chairman, could I ask you to have Mr. Hochheiser bring the subcommittee up to date on the possibility of this project?

Mr. CALVERT. Certainly.

Mr. ABERCROMBIE. Thank you.

Mr. CALVERT. We will do that.

Mr. ABERCROMBIE. Thank you, Mr. Chairman.

Mr. CALVERT. I want to thank the panel once again and invite our second panel. Dr. David W. Houseknecht, Program Director for Energy; Mr. Thomas Readinger, Deputy Associate Director for Resources and Environmental Management; and Mr. David F. Morehouse, Senior Petroleum Geologist.

Thank you, gentlemen. First, David Houseknecht. You may begin your testimony.

STATEMENT OF DAVID W. HOUSEKNECHT, PROGRAM DIRECTOR FOR ENERGY, U.S. GEOLOGICAL SURVEY

Mr. HOUSEKNECHT. Thank you, sir. I am going to stand in the interest of time. My name is David Houseknecht. I am the energy program coordinator for the USGS.

As part of its mission to assess the energy and mineral resources of the nation, the USGS periodically conducts an assessment of oil and gas resources in the on-shore and state water areas.

In February 1995, we released the results of our most recent study. You will be seeing some of those results this afternoon.

Our counterparts at the Minerals Management Service are responsible for assessing similar oil and gas resources in the Federal offshore, and you will be hearing from them next.

In the interests of time, I am going to not spend very much time on the technology and the methodology that we use in conducting our assessment. Just let me point out that it has been described in both a 20-page circular summarizing the results of our information, of our assessment, and also an interactive CD-ROM. This material that is abundantly available. We have a box of it here and would be happy to supply that to anyone who is interested.

What I would like to do is make three points regarding the methodologies that we use in our assessment. First of all, we start with the fundamental geology of the nation, and in doing that, we use something called a hydrocarbon play on which we base our assessments. A play is simply a set of either confirmed or hypothetical oil or gas accumulations that share common geologic attributes.

Secondly, once our geologists and geophysicists had defined plays across the county, they were extensively reviewed, first by state geological surveys in each region of the country, and then by a committee of the American Association of Petroleum Geologists, so we had a lot of participation in helping define the geology that is the basis for our resource assessments.

Thirdly, I think it is important to understand that any time we or anyone else assesses undiscovered resources that there is uncertainty involved in that process. I would like to point out, using this chart, a few things about the uncertainty of estimating oil and gas resource potential of an area or of the nation.

I have here probability distributions for two of the plays that we released information for in our assessment last year. One play, shown with the red line, is in a relatively well-known area where there has been a lot of exploration activity. It is in the Wyoming Thrust Belt.

What I would like to point out is that play is relatively well-constrained. There is not as much uncertainty in that play as in others, because of the abundant data that are available in that area. What I have shown with a dot here is that the mean resource estimate that we have made for that play is about 249 million barrels of oil, so we expect that much oil remains to be discovered.

However, the mean does not capture the uncertainty of the estimate, and it is important to understand that there is a very high probability that there is relatively little oil, and what I have shown here is what we would consider the 95th percentile. In other words, there is a 95-percent chance, in our opinion, that there will be at least 83 million barrels discovered in this play in the future, and at the low end of the distribution, there are higher resource and higher risk potentials, so we are saying that at the five-percent probability level, there is the likelihood of 465 million barrels being discovered. So there is always uncertainty until the area or the play is tested by drilling.

The other play that I have put up here is a play in a frontier area in southern Alaska, and what I want to point out is that the mean of this distribution is lower than the play in Wyoming; however, the upside potential is much greater. This is a play where there is a lot less information, and so as a result of that, the estimate that we make is more uncertain than the previous estimate that we have made.

So even though the mean estimate for this second play is 173 million barrels of oil, there is an upside potential, we think, a five-percent probability, that there will be 739 million barrels discovered.

I think it is important to understand that any time we are attempting to communicate estimates of oil and gas resources in undiscovered categories that that uncertainty needs to be understood.

Now, let us move on to some results. What I will do is, first of all, I will characterize the results of our oil and gas assessment by resource category. The bottom line is shown at the bottom of this set of pie diagrams in white.

We believe that there remains in the U.S. on-shore and under state waters, 142 billion of technically recoverable oil resources, and we believe that there remains over 1,000-trillion cubic feet of technically recoverable natural gas resources.

The pie diagrams show the distribution of those resources by resource category. In both cases, the darker colors are measured or proved reserves. Those are numbers that are reported by the Energy Information Administration, and we simply report them in our assessment results for the sake of completeness.

The next darker color is what we call reserve growth. This is also referred to as inferred reserves by many people. This is what we anticipate to be squeezed out of existing fields by the application of advanced technology and by various other techniques that are at use and will be developed for use in the petroleum industry in the future.

What is important to note is that on the oil pie diagram, the two darker-colored segments represent 70 percent of the resource base that we have estimated. On the gas pie diagram, the two darker portions represent 43 percent.

What we believe in those numbers is that the majority of the oil to be produced in the U.S. in the future and well over 40 percent of the natural gas to be produced in the future will come through fields that are already in existence through the application of advanced technology.

That is important to understand for land use considerations, because the activity in those fields will likely be concentrated where it has been in recent years.

In both pie diagrams, the two lighter colored segments represent the two categories of undiscovered resources. Those two categories include what we call conventional resources. Those are oil and gas accumulations that form in domes and have as a bounding lower surface an oil-water or gas-water contact. These represent the traditional fare of the petroleum industry.

The second category is what we call continuous type resources. These in the past have been called unconventional by some people. We believe that these are a significant resource, particularly in the gas category, and these differ from the conventional type accumulations in that they are widely distributed rather than in discrete accumulations bounded by a hydrocarbon water contact.

The next map that I am going to put up shows our estimates region-by-region of the Nation for those latter two categories of resources, so this represents a map showing region-by-region of the

country our estimates of the undiscovered resources of oil and natural gas.

Also shown on this map in shaded area are lands that are under Federal stewardship so that we can make a comparison between where the resources are, in our opinion, and what lands are under Federal jurisdiction.

In the oil category, there are two regions that stand above the others, Region 1, which is Alaska; and Region 6, which is the Gulf of Mexico. Both those regions, we believe, contain about 10 billion barrels of undiscovered oil. The third region that I will point out is Region 4, which is the Rocky Mountains and northern Great Plains where we believe that is about 8 billion barrels of oil remaining to be discovered.

Certainly, in Region 1 and Region 4, a large proportion of the land or a significant proportion of the land is under Federal jurisdiction. In addition to that, in Region 6, much of the land is in environmentally sensitive areas such as coastal wetlands.

If we turn to natural gas, the story is just a little bit more complicated because of the importance of the so-called continuous type resource base that we have made an estimate of.

Two regions of the Nation have large conventional natural gas potential, Region 6, which is the Gulf of Mexico, at about 106 trillion cubic feet; and Alaska, at about 68 trillion cubic feet.

Three additional regions have large natural gas potential where a large proportion of that gas base is of the unconventional or continuous type accumulations, and that includes the Rocky Mountains and northern Great Plains with 195 trillion cubic feet. Over half of that is in the Greater Green River Basin, which we heard about in the previous testimony. Region 8, the eastern part of the Nation with 114 trillion cubic feet of gas potential; much of that is locked in tight shale formations and in coal bed methane accumulations; and finally, Region 3 that has about 65 trillion cubic feet of gas potential, and where significantly, a very large portion of the land is under Federal stewardship, and in that area, much of the gas resource is in tight gas sands or in coal bed methane accumulations.

In summary then, the USGS believes that on the on-shore and state water portions of the United States, there remains a significant potential for oil and particularly for natural gas to be discovered. In addition to that, the distribution of those resources tend to be in areas that are either very largely under Federal jurisdiction and stewardship or are in areas that have substantial environmentally sensitive lands in which exploration would need to take place.

Sir, I would ask that my entire testimony be entered into the record, and I thank you for your attention.

Mr. CALVERT. Without objection. So ordered.

[Statement of David W. Houseknecht may be found at end of hearing.]

Mr. CALVERT. Thank you for your testimony. Next, Mr. Thomas Readinger.

STATEMENT OF THOMAS READINGER, DEPUTY ASSOCIATE DIRECTOR FOR RESOURCES AND ENVIRONMENTAL MANAGEMENT

Mr. READINGER. Good afternoon, Mr. Chairman and members of the subcommittee. I am pleased to have the opportunity to be here today to discuss OCS oil and natural gas resources and our estimates of those.

Accompanying me today is Paul Martin, who is the chief of our MMS resource evaluation division.

As you are aware, the OCS oil and natural gas program contributes significantly to the nation's economic well-being and our energy security. Of the roughly $4 billion generated annually from mineral activities on Federal lands, OCS receipts make up about three-quarters of that amount. Further, about 24 percent of our domestic natural gas production and 15 percent of our domestic oil production comes from the OCS.

As manager of the nation's OCS energy and nonenergy mineral resources, one of MMS's responsibilities is to assess the most promising areas of the OCS for the occurrence of oil and natural gas and to quantify the amounts of oil and gas that may exist there.

Further, we also develop indicators of the economic viability of these resources under a variety of price and costs and areas.

Since MMS was created in 1982, the Bureau has completed two systematic assessments of Federal OCS undiscovered oil and natural gas resources, and it is in the process of finishing up our third assessment.

Because we are still in that process of completing the current analysis which will incorporate, by the way, a new technical estimation methodology, I am unable at this particular time to provide the subcommittee with the results of that analysis. However, the Bureau hopes to complete and release our results in the next few months, and I can assure you that we will provide these results to Congress as quickly as they are available, and we would be happy to brief any interested members or staff.

I can say at this point that it appears from our preliminary analyses that our resource estimates for the OCS as a whole will increase for both oil and natural gas. This is not really a surprising result, given that the reviewers of our previous assessments advised that the methodologies we used tended to pretty much understate resource potential.

From previous assessments, we have estimated that the OCS contains roughly one-third of the nation's undiscovered oil and natural gas resources. That percentage, as I was alluding to previously to here, is expected to increase somewhat, which means that the OCS will continue to play an important role in the nation's domestic energy picture for the foreseeable future.

In your letter of invitation, Mr. Chairman, you asked that I discuss a little bit about our methodology. In the interest of time, I will just briefly point out a few things.

The decision to modify our methodology and go to this new approach was really made in late 1991 following peer reviews of our second assessment which was about 1990, and some of these reviews came from organizations, such as the National Academy of

Science, the Association of American State Geologists, API, EIA and others.

Second, we took a serious look at how we use resource estimates as well as how other parties may use the estimates and tried to develop a methodology that would respond to those needs.

MMS is somewhat unique in that not only do we prepare OCS resource estimates, we are also a primary user of those estimates. For example, resource estimates are an important component in releasing program decisions, our regulatory environmental analyses, and for other planning purposes.

However, we also recognize that this information is important to our customers and state agencies, other Federal agencies, industry, academia, and the public and others. For these reasons, we have endeavored to develop a methodology that is easy to understand and useful to decisionmakers and the public, and that also reflects the highest quality science.

Our new methodology attempts to maintain the strong points of our previous estimation approaches, which were partly commended by the National Academy; to utilize the extensive proprietary information base we have; and the technological advances that have been achieved in the private and public sectors; and to allow our professional geologists to exercise broad judgment to capture a range of possible geologic interpretations. This latter point is in direct response to recommendations received on our prior assessments from the National Academy and others.

Our new approach, called Geologic Resource Assessment Program, or GRASP, is a modified version of a play analysis methodology currently used by the geological survey of Canada. It is useful because it can provide an estimate of the number and sizes of pools that remain to be discovered, as well as provide estimated resources in the aggregate.

After an extensive review of alternative methodologies available, MMS selected this Canadian methodology based on an evaluation of our uses, the uses of our customers, and comments received from the National Academy and others. Further, this methodology has been in use for several years by the Canadian government and has undergone technical review by members of international geoscience community.

MMS implemented a number of changes to this methodology to tailor it for our resource estimation uses. One goal that we were looking at was to allow users to determine and compare the impacts of different price and cost scenarios when determining the amount of resources which may become economically available for different portions of the OCS. That is, we would provide some base geologic information and then allow different distributions based on whatever assumptions the public may want to apply as far as cost or prices.

One of the principal advantages of the new methodology is it will allow our professionals to capture conceptual possibilities of hydrocarbon occurrences and not be conservatively limited to those which have been actually mapped.

We believe that this approach represents the best science available for determining undiscovered OCS oil and gas resources, and that the results obtained from this approach will be more useful to

our customers as well as ourselves, thereby contributing to efforts to develop balanced resource management policies affecting OCS resources for the future.

Mr. Chairman, this concludes my prepared remarks, and I would be happy to answer questions at such time.

[Statement of Thomas Readinger may be found at end of hearing.]

Mr. CALVERT. Thank you, Mr. Readinger, for your testimony.

Mr. Morehouse, we would like to go ahead and get your testimony before we take off to vote.

Mr. MOREHOUSE. Mr. Chairman, I would ask that my full statement be placed in the record.

Mr. CALVERT. Without objection. So ordered.

STATEMENT OF DAVID F. MOREHOUSE, SENIOR PETROLEUM GEOLOGIST, ENERGY INFORMATION ASSOCIATION

Mr. MOREHOUSE. Mr. Chairman and members of the committee, I appreciate the opportunity to appear today to discuss domestic oil and gas resources, proved reserves and production, and EIA's efforts to track, analyze and project them.

With me is James Deimer from our Office of Integrated Analysis Forecasting, who will assist with the slides and questions that I can't answer on the modeling functions.

I will cover: first, recent trends in the domestic production and proved reserves of crude oil, natural gas liquids and dry natural gas; second, the linkage and implications of the EIA reserves program's outputs to and for the assessment of undiscovered domestic oil and gas resources; and third, EIA's projection of the extent to which domestic oil and gas supply as opposed to imports will satisfy the nation's energy through 2015, which in part depends on the volume and characteristics of the estimated remaining oil and gas resource base.

Before continuing, I would like to note that EIA is an independent agency of the Department of Energy charged with providing objective data, analyses, and forecasts relative to energy matters. EIA does not take a position on any policy proposal and is free to disseminate that which it believes to be true and informative.

Looking at the first slide, United States crude oil production peaked in October 1970, at a rate of 10 million barrels per day. From 1977 through 1995, it declined overall at almost 1.2 percent per year. Including liquids extracted by natural gas processing plants, total petroleum liquids production also decreased in the same period at a lesser average rate of .9 percent per year.

Going to the second slide, domestic production of dry natural gas peaked in 1973 at 21.73 trillion cubic feet declining to a post–1966 low of 16.09 trillion cubic feet in 1986, and then increased, though not in every year, to 18.72 trillion cubic feet in 1995.

These production statistics are developed monthly by the producing states and the Minerals Management Service. Accurate and verifiable estimates of the proved reserves from which production comes have been generated annually since 1977 by EIA. They are survey-based and require nine months to produce, so the most recent are for December 31, 1994.

Proved reserves are those quantities which geological and engineering data demonstrate with reasonable certainty to be recoverable in the future from known reservoirs under existing economic and operating conditions.

I will not directly address EIA's reserves program, but information about it is included as exhibit A of my formal statement. I would be pleased to answer any questions you have about it.

Going to the next slide, domestic proved reserves of crude oil generally declined over the 1977 to 1994 period, from 31.78 trillion barrels to 22.46 trillion barrels, 29.3 percent overall, and an average of 1.7 percent per year not compounded—it is about two percent compounded, I believe—as illustrated on the slide which also indicates the component proved reserves estimates for major geographic subareas.

Proved reserves of natural gas liquids were 6.62 billion barrels in 1979, increased 24.5 percent to 8.24 billion barrels in 1988, and then decreased again 13 percent to 7.17 billion barrels in 1994.

Going to the next slide, proved reserves of dry natural gas, when adjusted prior to 1988 for the removal of 24.6 trillion cubic feet located in Alaska's Prudhoe Bay Field, which were debooked in 1988 for economic reasons were 182.81 trillion cubic feet in 1977 and decreased only 10.4 percent to 163.84 trillion cubic feet in 1994, a .6 percent per year decline rate.

Internationally, the United States ranks 11th in crude oil proved reserves behind each of five Persian Gulf countries, the former Soviet Union, Venezuela, Mexico, Libya, and China. It ranks sixth in natural gas proved reserves behind the former Soviet Union and each of four Persian Gulf countries.

Estimated ultimate recovery from the nation's oil and gas resources is defined as the sum at a point in time of all production to that time and the estimate of proved reserves at that time. Figures 6 and 7, which I do not have slides of here but are in the formal statement, show the steady growth of domestic estimated ultimate recovery from 1977 through 1994 for crude oil and wet, not dry, natural gas. The portion accounted for by proved reserves is decreasing over time in both instances

That then is the general proved reserves and production picture for the United States over the recent past. It reflects slowly decreasing domestic proved reserves and production of crude oil and natural gas liquids, and decreasing, though at a lesser rate, proved reserves of natural gas.

We may be at a turning point for natural gas in that the number of exploratory gas well completions has been increasing since 1992, gas production, excepting 1991, has been increasing since 1986, and proved gas reserves managed to follow suit in 1994.

I turn now to the subject of undiscovered resource estimation and the linkages between the EIA's reserves work and other's resource estimation work. EIA collects estimates of proved reserves by field from the larger operators of domestic oil and gas wells. Reservoirs are the natural unit of occurrence of liquid and gaseous hydrocarbons in the subsurface, as David Houseknecht described.

A field consists of one or more reservoirs grouped on or related to an individual structural or stratigraphic condition. The largest operators are required to file proved reserves estimates by field,

and while intermediate-size operators are required to do so only if they maintain such estimates, most do. Together, they accounted for 92.6 percent of domestic crude oil proved reserves and 94.2 percent of domestic proved reserves of dry natural gas as of December 31, 1994.

Through its reserve survey, therefore, EIA has obtained a fairly complete picture of the United States proved reserves situation at the field level of estimate aggregation over a period of 18 years, and it has accurately matched these estimates field-by-field with production data obtained from State sources and the Minerals Management Service to create its Oil and Gas Integrated Field File. While this file contains proprietary data and therefore, is not releasable to the public, alone and in conjunction with additional geologic and engineering data, it provides the basis for useful, publicly releasable analyses of many kinds.

For example, the EIA annually provides a derivative product which presents estimates of crude reserves and production aggregated by county or parish in those instances where the number and relative sizes of the reporting operators precludes identification of individual responses.

This product——

Mr. CALVERT. Mr. Morehouse, I apologize, and ask you to suspend, but we have to walk over and vote. If you could just recess for a few minutes, and we will be back as soon as we vote on the Chrysler amendment. Thank you very much.

[Recess]

Mr. CALVERT. We are back in order. Mr. Morehouse, please continue your testimony.

Mr. MOREHOUSE. The other principal use for the oil and gas integrated fuel file is that it is an input to estimating ultimate oil and gas resources with respect to both undiscovered fields and the appreciation of ultimate recovery in known fields over time.

Even with a simple visual examination of the size distributions of fields in sufficiently large areas, you can tell a lot about the prospects for that area.

We will quickly go through four slides here that show you what happens.

The first slide is the size distribution of crude oil fields in the United States. It has 26,000-plus fields shown in it. It is a classic distribution that you get for a maturely explored area, which is to say it is smooth; it is positive skew, and it is negative exponential to the right of the peak or the mode of the distribution, reflecting the fact that there are very few big fields and a lot of small ones. The left side rolls off because you don't see the fields reported in that area due to economic cutoffs. They are never reported as proved reserves.

We will go to the next slide. Most of the continental United States areas, geologic basins, provinces, however you wish to aggregate them, are fairly mature to mature. This is an example of the Mid-Continent region. Here, we are looking at a little over 10,000 fields, and it very much looks like the United States distribution in terms of maturity, not quite as much, but just about.

Let us now look at a couple that aren't mature yet. There are essentially three areas in the country that are not mature. The first

one is what we define as the Far West region, which is essentially California, Oregon, and Washington, both on-shore and offshore, parts of Idaho, and I think there is one other area, parts of Nevada and Utah. Here, you don't have the nice, smooth distribution with a well-developed mode to it that is positive skew.

Look at the next one. This is the Alaskan region, on-shore and offshore. Again, you don't have the nice, smooth, filled-out distribution with a positive skew to it.

Those two areas plus the Gulf of Mexico, particularly in the hingeline area, sloping off into deep water and the deep water itself, and possibly the Atlantic, although we don't have any data there because there have been no discoveries there yet, are the four areas left in the country that are immaturely explored. That is where you can expect to find some large fields that are of national supply significance as opposed to fields that are simply of local, commercial significance. These same findings are mirrored in the Geological Surveys and the Minerals Management Service results.

Finally, the estimated element recoveries of most oil and gas fields appreciate over time for a number of reasons that are mentioned in my formal testimony. Over the past 17 years, 93.6 percent of additions to domestic crude oil reserves and 86.3 percent of additions to domestic dry natural gas reserves have been due to ultimate recovery appreciation, not to the discovery of new fields, which in both cases was less than 15 percent.

It is important, therefore, when you are projecting ultimate recoveries and future production to know what is going on with respect to ultimate recovery appreciation.

Prior to the current go-round of the GS's work, they had to rely on a data series which was not geologically based but state-based, produced by the American Petroleum Institute and the American Gas Association regarding ultimate recovery.

Since we have developed the oil and gas integrated field file and made arrangements for them to use it, while protecting its confidentiality, they have made substantial changes in their estimates of inferred or fuel growth resources.

In fact, over the next 80 years, they are projecting 60 billion barrels of crude oil; 13,400 million barrels of natural gas liquids; and 322 trillion cubic feet of natural gas from that source. Those are 184 percent more for crude oil; 253 percent more for natural gas liquids; and 247 percent more for natural gas than those from the prior national assessment.

Let us turn now to the EIA's projections of the nation's energy future through 2015. This is presented in the annual energy outlook of 1996, and these are based in part on the estimates of resources produced by USGS and MMS, the National Petroleum Council for Gas, and in some part by the Department of Energy's Office of Fossil Energy. These projections assume that existing land withdrawals and drilling moratoria would continue indefinitely.

The reference case forecast for a world price in 2015 is $25.43 per barrel. The high world case is $32.61 per barrel in 2010 and $33.89 in 2015; the low case, the price drops for a few years and then regains its present level through 2015.

In all but the high-price case, net imports of both oil and gas grow to fill the difference between domestic supply and consump-

tion. In the reference case, the growth in net natural gas imports increases from 12 percent of total gas consumption in 1994 to 14 percent in 2015, and that is far less than the growth of net oil imports, from 45 percent of oil consumption in 1994, to 56 percent in 2015.

When high world oil prices are assumed, little change is expected from the current balance and continued low oil prices could lead to an import share as high as 68 percent in 2015.

In the reference case, U.S. oil production declines over the project period. The projection for domestic crude oil production declines by 21 percent from 1994 to 2005 as depletion of domestic oil resources continues. From 2005 to 2015, production increases by 11 percent as prices rise, stimulating overall drilling and the cumulative effects of improved technology extend development efforts to more costly resources.

Estimated oil production is projected to bottom out at 5.3 million barrels a day in 2005, rising to 5.8 million barrels a day in 2015.

Driven primarily by growth and consumption, natural gas production increases at an average annual rate of 1.3 percent between 1994 and 2015. Expanded production over time, the degree of flex, the combined impact of slightly rising prices, relatively more abundant natural gas resources and improvements in technologies, particularly for unconventional gas recovery and offshore projects.

Imports of gas, mostly from Canada, satisfy some of the increase in demand. Canadian producers are projected to gain market share over the forecast period as natural gas imports expand from 12 percent of total gas consumption in 1994, to 14 percent in 2015. Key assumptions regarding rates of technological advancement and other factors have significant effects on these projections. The principal ones are addressed in my formal statement.

Thank you for the opportunity to testify about the nation's oil and gas resources, reserves, and production, and the applications for the future. I will be happy to take any questions you may have.

[Statement of David F. Morehouse may be found at end of hearing.]

Mr. CALVERT. Thank you, Mr. Morehouse. We have a few questions for the panel. First, Mr. Houseknecht, for the record, could you please briefly describe the qualifications of yourself and other members of the team which comprise the U.S. Geological Survey's national oil and gas estimates?

Mr. HOUSEKNECHT. Certainly. I hold a Ph.D. in geology from Penn State University. I spent 14 years as a professor at the University of Missouri, rising to the rank of full professor. I came to the USGS four years ago to manage the energy program, and in addition to my academic experience, have worked cooperatively and consulted extensively with the oil industry, both domestically and internationally while I was in the academic world.

The USGS oil and gas assessment team that conducted the assessment that you have seen the results of today involved more than 55 individual scientists located across the country. Many of these are Ph.D.s in geology, geophysics, or geochemistry. In addition to that, we have a team of mathematicians, statisticians and economists who also contribute to the results.

Mr. CALVERT. In your testimony, you emphasize the uncertainty in establishing undiscovered oil and gas resources. How can that uncertainty be reduced? Is there a way to do that?

Mr. HOUSEKNECHT. You bet. Additional data is the only way to reduce uncertainty. Those data can come from many places. They can come from acquisition of seismic data that was not previously available. They can come from additional fieldwork.

Certainly, the ultimate test of the uncertainty of an area comes from drilling test wells.

A good example of the effects of that in reducing uncertainty is a recent discovery that has been made in the Williston Basin in North Dakota. In our national assessment that I presented here, we lumped together a number of limestones of Mississippi in age under the banner of the Madison limestone play. The Madison has been a prolific oil reservoir in that area for some time. We really didn't have any information or data about older units in that particular area of North Dakota.

About two years ago, a well was drilled deeper and a significant discovery was made in what is called the Lodge Pole formation as a result of establishing production of about 2,000 barrels per day from that discovery well, and that sparked a renewed interest in the area, deeper drilling, and that has resulted in substantial significant field discoveries in at least three or four other areas.

That is just one example of how uncertainty can be reduced by additional data. If you look at the results of our 1995 assessment, we estimated quite a large range of uncertainty for that limestone play, from about 13 million barrels at the 95-percent confidence level to over 300 million barrels at the five-percent confidence level. With this additional data, that uncertainty will be reduced and probably the mean recoverable resources that we estimate for that particular area of the country will increase.

That is just one good example of how uncertainty can be reduced by drilling into new rock layers that have not been penetrated by previous exploration.

Mr. CALVERT. Thank you. Mr. Readinger, you have explained in great detail the compilation process for the resource data. What is the next step? In other words, what do you do with this data and how does this work benefit ultimately the taxpayer?

Mr. READINGER. I guess as I was explaining in our testimony here, I think there are important decisions that need to be made, and some of these decisions on where to lease, how to regulate, environmental impacts and so on involve substantial economic resources and substantial economic value, and therefore—and ultimately could even risk certain environmental dangers and so on. Therefore, an accurate assessment of geology is very important in the balancing decisions involving this very substantial resource.

One of the most important uses is the decisions we make on where to lease, how to regulate and so on.

One very important aspect and use of our numbers has to do with our determinations for fair market value. When you are dealing with a program of billions of dollar of value received, $4 billion or so a year, it is important that the estimates we do can give the public confidence that we can assure receipt of fair market value, so that is another aspect, and there are others.

As I mentioned in the testimony, there are also users in the private sector, in academia, and others who also have some use of it, but the primary use has to do with the decisions we make on where to lease, how to develop the regulations, and how to assess impacts from the program and ultimately, that feeds into our documents that the Secretary and others use for these decisions.

Mr. CALVERT. Thank you. Mr. Thornberry?

Mr. THORNBERRY. Dr. Houseknecht, do you know how much approximately total crude oil has been produced domestically in this country?

Mr. HOUSEKNECHT. Yes, I do. I think about 170 billion barrels.

Mr. THORNBERRY. So we don't have quite as much left under your number as we produced, although some people make that argument or that estimation, we have got about as much left as we produced.

Mr. HOUSEKNECHT. Bear in mind that the numbers that we have reported, the 142 billion only represent the on-shore and state water portion of the resource base. The entire nation's picture has to be captured by also incorporating the Federal offshore numbers, so that total would increase substantially.

Mr. THORNBERRY. Let me ask this, so I can get a better handle on it, and whoever may know. What percent of our current production is off Federal land, and if you can break it down, on-shore, offshore, that is fine; if you can put it together, that is fine, too.

Then my next question is going to be, how much of our reserves are on Federal land?

You kind of broke it out by region, but can you give me a basic percentage on, what I am looking for is, how important Federal lands are in our energy picture?

Mr. HOUSEKNECHT. I will have to pass on the first question. I do not know the answer to that one. What I will say about the resource, remaining resource base on Federal lands is that as part of conducting this current national assessment, we have captured all of our play boundaries in GIS format, geographic information systems format, so we now have digital boundaries.

We are working with land management agencies on a region-by-region basis to also capture in digital form the land boundaries of the lands that are under their stewardship, so we are actively working toward making estimates of how much of the oil and gas resource base would occur on Federal lands.

We do not have that completed yet. We will have that completed later this year, and would be happy to furnish that information at the time.

Mr. THORNBERRY. Do you have any better estimates about what percent of production or reserves is on Federal land?

Mr. READINGER. Speaking from the offshore, as I indicated in my remarks, we are responsible for about 24 percent of domestic natural gas production and about 15 percent of domestic oil production.

Overall, that roughly, I believe, represents about three-quarters of the production from Federal lands. I don't know, Dave, if you have a total number there.

Mr. MOREHOUSE. The problem is that the more we break out the Federal OCS separately in the reserve survey work, we do not break out on-shore Federal——

Mr. THORNBERRY. You don't break out on-shore——

Mr. MOREHOUSE. Right. I could——

Mr. THORNBERRY. [continuing]—Federal reserves.

Mr. MOREHOUSE. [continuing]—give you the reserve numbers in '94 for the Federal OCS and the total for the country so you can strike a percentage there.

Mr. THORNBERRY. But nobody that you know of breaks out the on-shore, too.

Mr. MOREHOUSE. Not on Federal land, no. I would presume that BLM, for instance, has some production data on Federal land.

Mr. THORNBERRY. Let me ask you this. It seems to me in listening to all your presentations, and all of you admitted, there is a fair amount of uncertainty in what you are trying to do, although it is very important.

Some of the variables include, of course, the prices of oil, and I know you have made some assumptions about that. What is also included is the technology that is available. Obviously, as we heard from the Department of Energy earlier that this wonderful new technology that is coming along may make it easier to produce from places we could never produce before.

But what else is a variable is the cost of production, because the economics have to figure into it, and what we are seeing today is lots of marginal wells being closed up. The oil may be there, we know it is there, it is counted in the reserves, but it is not economical to produce it, so it is not going to do us much good.

So the whole question of cost of production and the way the Federal Government adds to the cost of production through regulations and so forth is certainly a question of concern.

Can each of you, if you care to, comment on the uncertainty that all of those variables bring into what you are trying to do?

I know in your presentation you had a high cost and low cost of $25 to $32 on the price of oil, but these other things impact it, too, and it seems to me that those are key players in whether we are able to produce all of what we are capable of. Do you agree or not?

Mr. HOUSEKNECHT. I will go first. Absolutely. First of all, the numbers that we have presented are independent, more or less, of pricing. We consider these numbers to be technically recoverable numbers; in other words, these are resources that could be produced from the earth's crust using existing technology through a bore hole regardless of price.

We are now doing a derivative study, region by region in the country, that will result in a series of price supply curves that will be superimposed on this resource.

What I can say, though, is that clearly, when 70 percent of our resource base resides in existing fields and our anticipated growth of those existing fields, and 43 percent of the natural gas base resides in those areas, it is very critical that technology development and economic thresholds be considered in determining what proportion of that resource base will ultimately reach the consumer.

Mr. READINGER. One thing I think I could add to this, I think when our new assessment comes out, we will be providing what we call these price supply curves, so the public and ourselves will be free to look at sensitivity of the resource estimates based on different cost scenarios.

If a technology becomes available, say in 3D seismic, which we heard earlier from DOE, has not necessarily reduced the cost per well, but has made the success rate of each well greatly higher.

We can look at that reduced cost as an output. You can just simply look up in the curve and see how much more resources you will have received for each of those kind of cost-reducing initiatives.

That is one of the things we are excited about in this new assessment that we are doing, and that should contribute to a lot of these policy questions that you may have in your mind and others.

Mr. MOREHOUSE. Yes, I think if you look at figure 15, if you have a copy of the formal testimony, you will see that there is a graph of crude oil production for three different technology cases: the high technology case, the low technology and reference, essentially, they change by about 50 percent in effectiveness.

The technology affects things like drilling costs. It also affects things like the expansion of the resource base and other factors. Similarly, I think you will find that it will also affect abandonment rates. You will also see that affect abandonment rates, so essentially, this is built in through the technology end of it in the models.

Mr. THORNBERRY. But, Mr. Morehouse, in any of your analyses, did you try to evaluate a lower and higher regulation compliance cost?

Mr. MOREHOUSE. No. We are producers.

Mr. THORNBERRY. Which is another variable we all have to deal with, too. Thank you.

Mr. CALVERT. Thank you, Mr. Thornberry, and thank you to this panel for testifying. You are excused. We appreciate your testimony.

I would like to invite panel three for independent estimates. Dr. Lyle Baie, Executive Director, American Association of Petroleum Geologists; Mr. David Webb, Vice President for Policy and Regulatory Affairs, Gas Research Institute; and Ms. Denise Bode, President, Independent Petroleum Association of America.

I would like to thank you for agreeing to testify today, and invite Dr. Baie to begin his testimony. Thank you.

STATEMENT OF DR. LYLE BAIE, EXECUTIVE DIRECTOR, AMERICAN ASSOCIATION OF PETROLEUM GEOLOGISTS

Mr. BAIE. Mr. Chairman, my name is Lyle Baie, and I am here representing the American Association of Petroleum Geologists. This is an international professional organization representing the needs of geoscientists working in the fields of petroleum, energy minerals, general geology, and the environment.

The AAPG was founded in 1917, and currently has around 31,000 members, down from 45,000 members in 1985. Most of our members, 75 percent, work in the United States for either major oil companies, independent oil companies, as consultants or as independents. Many others are self-employed, students or educators at the university or high school level. Others still work in the fields of environmental science, as well as in the government, both local, state and Federal.

It is the charter of AAPG to advance the science for its practitioners by providing educational opportunities for our members,

promotion of technology in use for exploring for oil, gas and minerals, the fostering of research in those same topics, the dissemination of information, the setting of high professional standards, the enhancement of the public standing of the professional geologist, and the advancement of the well-being of our members.

The interests of AAPG in national energy policy flows from our members' 79-year involvement in the course and direction of petroleum and energy-related industries in the United States.

As you are well aware, the state of health of our nation's oil and gas production is not good. As companies continue downsizing and focusing their resources into the international arena, domestic imports will continue to rise, making oil supply security an area of concern to each of us.

At the heart of many of the changes our industry has undergone is the widespread perception that our nation's oil and gas resource base has been thoroughly evaluated and developed and that all the Federal and state initiatives for increasing domestic oil and gas production have been exhausted.

This perception must be modified by examining two principal trends. First, advanced technology allows us to recover increasing amounts of the oil in place. Oil in place is the important number, and as we improve our technology, we can recover more and more of that resource.

Equally important is the resource base contained in new fields, trends or plays currently not known or evaluated.

As Mr. Houseknecht said in his presentation, the AAPG, through its Committee on Resource Evaluation, has been cooperating with the USGS along with individual state geologists regarding the issue of our nation's oil and gas resource assessment. This tripartite approach has, for example, led to a simplification of the play concept basis for the resource evaluation of known producing oil and gas trends or plays. These groups will continue to cooperate in the next assessment cycle.

Through AAPG's involvement in this depth involvement with the current methodology being employed by the USGS for the assessment of our nation's oil and gas resources in currently known play areas, we can conclude that both the methodology and the resource numbers are supportable.

It is in the other area of unknown—as again, Mr. Houseknecht pointed out in his presentation—areas that we currently don't identify as petroleum resources, because we don't have an example of a producing field. It is important to get these particular new areas like the Lodge Pole that he mentioned, into our assessment process.

These have been called hypothetical plays in the past. It uses a system called petroleum systems analysis, and it allows us to go into areas where there is not production at this time and develop at least a rough assessment of what may be there.

The driving forces for increased success in our exploration efforts in the United States falls into at least three different categories. The first is government policies that would encourage domestic oil and gas exploration and production, especially as these polices are related to public lands and the Outer Continental margin. This is

primarily a question of physical and financial access by the exploration companies.

Second is advanced training for the professionals who will lead the exploration and production industry in the 21st century. This particularly is a role that AAPG and other professional societies already play.

Most significantly, however, is the role our government might take working through the USGS and what I call the tripartite advisory council, which includes the USGS, the AAPG, and the state geologists, to document and evaluate new play concepts and new potential exploration areas, and then by using established communication channels already in place through organizations like AAPG to communicate these ideas to the initiators of exploration efforts within the petroleum industry itself.

AAPG, for example, has established recently an E&P format within our AAPG bulletin publication which is distributed monthly to 31,000 members, not just in the United States but around the world.

By extension, this same format could be used to publish new potential plays and trends based on sound scientific principles and evaluation techniques thereby allowing this information to get into the hands of the exploration community at large.

Our industry is known for its ability to flock to areas where new reserves have been discovered. That can be stimulated, I believe, by providing some basis for evaluating basins not just those we know could produce, but those that might be available through new concepts, new ideas, new technologies.

This latter approach could stimulate domestic exploration by leading to the definition of new resources for development, possibly slowing the growth of imports.

Thank you.

Mr. CALVERT. Thank you, doctor. Next, Mr. David Webb. You may begin your testimony.

STATEMENT OF DAVID WEBB, VICE PRESIDENT FOR POLICY AND REGULATORY AFFAIRS, GAS RESEARCH INSTITUTE

Mr. WEBB. Thank you, Mr. Chairman. The Gas Research Institute appreciates the opportunity to testify. GRI is the research and management arm of the natural gas industry. We conduct research for approximately $175 million a year in new natural gas supply and end-use technologies for over more than 325 member companies.

The gas industry has experienced significant changes over the past ten years due to deregulation; changes in the business structure, if you would; the increasing impact of technology on gas supply. Despite a decline of one-third in average wellhead price, and a reduction of 50 percent in drilling levels since the mid–1980's, U.S. gas production has increased 28 percent.

The ability of producers to meet increasing U.S. demand despite reduced drilling levels has resulted from both technology advances, the industry practices that increase the efficiency and reduce the cost, and expanding the recoverable resource.

In our latest projection of U.S. energy supply and demand, GRI estimates that this growth will continue. This total gas demand is

projected to increase from approximately 21 Tcf (trillion cubic feet) in 1994 to over 28 Tcf in 2015.

The experience since the mid–1980's is a drastic change from earlier projections. Through the early 1980's, gas decisionmakers focused on maintaining existing markets; new markets were not viewed as an option. In large part, this focus reflected the pessimistic outlook for gas supply.

Gas prices were expected to have to grow rapidly to justify drilling activity thought necessary to maintain even current gas supply, thereby putting many existing markets at risk.

The extraordinary success of the gas industry in expanding gas supplies and maintaining deliverability under the low prices of the last decade can be attributed primarily to the development and deployment of new technologies that have increased supply additions per unit effort.

Recovery per well is a good measure of industry's ability to efficiently discover and develop new reserves. Reserve addition data compiled by the Energy Information Administration (EIA) and by annual well counts compiled by the American Petroleum Institute (API) indicate that since the mid–1980's, recovery per well nationally has averaged about 1.5 Bcf. That is a 90 percent increase over the average of the previous ten years.

New technology has played a major role. Technology effects including 3D and advanced 2-D seismic, improved geological and drilling information, completion technologies, and directional drilling, which allows you to explore more than one region from a single well, all have contributed.

In the first half of 1995, more than one-fourth of U.S. gas wells were directionally drilled. That is double the rate since 1993.

To give you an illustration of the impact of technology on gas supply and production, in GRI's 1995 Projection of U.S. Energy Supply and Demand to the Year 2010, the lower 48 gas resource potential increases from about 900 Tcf using current technology assumptions, to almost 1,400 Tcf using assumptions of technology that could be available in 2010 if we continue to fund research and development.

Without any new technology advances, U.S. gas supply cannot be sustained at current levels after the year 2000. By the year 2020, U.S. gas supply would be 25 percent lower than it is currently without any new technology.

We think there is a continued role not only of groups such as GRI but of the Federal Government in funding research and development on gas resources and gas development technologies. With shrinking research and development budgets and dollars available, it is becoming increasingly more and more common to see companies, such as those that belong to GRI, pool their resources to participate in collaborative research, oftentimes in cooperative efforts with the Federal Government.

This practice should be encouraged. We encourage Congress as one element of national energy policy review to look at tax credits to encourage collaborative research. We think that would be a good way to encourage more collaborative research.

In summary, U.S. producers have met increasing new gas demand in the low price era over the past decade with 50 percent newer gas wells than in the past.

Four factors contributing to industry profitability since the mid–1980's are higher recovery per well, lower well and equipment cost, declining interest rates, and improved drilling success rates.

Three of these four factors are the direct result of continued technology advances. R&D is critical to the future of the gas industry in a continuing era of low energy prices. Because of past research, we are currently enjoying plentiful supplies of national gas even at declined and low prices.

To ensure the same stability for the future, R&D must be continued both on a Federal and a private level, and it should be encouraged by looking at policy initiatives such as collaborative research tax credits.

I want to thank the subcommittee for inviting me to testify. I would be happy to answer any questions or provide additional information to the committee. Thank you very much.

[Statement of David Webb may be found at end of hearing.]

Mr. CALVERT. Thank you. Next, Ms. Denise Bode, President, Independent Petroleum Association.

STATEMENT OF DENISE BODE, PRESIDENT, INDEPENDENT PETROLEUM ASSOCIATION OF AMERICA

Ms. BODE. Thank you, Mr. Chairman. As you know, IPAA represents over 5,000 oil and natural gas exploration and production companies doing business here in the United States. These independents drill over 85 percent of America's wells and also 59 percent of all the wells drilled offshore, which is a relatively new instance. We also produce 64 percent of the natural gas produced in the United States and 40 percent of the oil in the United States.

These hearings are extremely timely, considering the sad state of American energy policy with foreign oil imports soaring above 50 percent for the first time this last year, and now five years after the Gulf War over oil, where our policies haven't changed significantly.

I am here to share with you what we believe is a new way of thinking about oil and gas production in the United States and the role producers, particularly the independents that I represent, are playing in accessing and developing that vast resource base.

I also want to share with you our view of the role government must play in making this critical resource available to American consumers.

The old way of thinking about oil and natural gas production in the United States was based on elephant fields that gave rise to giant global corporations. Now, in the twilight of the 20th century, many of those companies are shifting investments overseas, still looking for giant fields.

But there is an abundant resource base remaining in the United States. America is not running out of oil and gas. New technological innovations have revolutionized exploration, drilling, and production processes, expanding our knowledge of America's vast potential for domestic oil and gas supplies.

What is the resource base? You have many other experts that will focus on this, but we believe that we are looking at a resource production ratio of 62 years for oil and 68 years for natural gas. Nearly half of the resource lies in new exploratory development and half in existing fields, and these vast resources will by and large be found and developed in small increments or jackrabbit fields, not in the vast elephant fields found in the Middle East.

In fact, America's remaining oil and gas resources are greater than our cumulative production from the year 1857 to present.

Recently, IPAA looked at our resource base and the trends in the industry that were impacting it in a study entitled "The Promise of Oil and Gas in America." The study analyzed natural oil and gas plays and trends with significant discoveries or developments in some 16 states.

Some important themes emerged that others have already enumerated. New reservoirs were often found with new technology, mostly improved seismic and 3D seismic data and better drilling and completion technology. Improved geological concepts were a critical new factor.

Drilling technology was also critical to the success of many projects, and this includes proper fracturing techniques, mud systems, economical drilling, and better logging and evaluation methods, and finally, reservoir characterization was critical to most infield drilling projects.

These are some very recent examples of how these advances in technology have continued to increase America's reserve base. The Gulf of Mexico subsalt is an example of a new resource made possible by 3D seismic technology, and in the Austin Chalk, advances in drilling technology have allowed us to get at the resource.

Others included in my written testimony include the North Dakota Lodge Pole and the Cotton Valley Reefs, both made possible through the use of improved imaging or 3D seismic.

The report also highlights an immense hydrocarbon frontier in the United States in some 50 basins or portions of basins in 38 states. Our resource base report shows that we can meet our country's needs for oil and gas for many years to come through intelligent and efficient exploration and development.

But to convert the resource into reserves and production on a time scale needed by the American economy will require a significant increase in industry effort. It will require the ability for producers in the industry to form sufficient capital to mobilize the rigs and create these jobs, and it will require an understanding by government of the changes in the players and the technology, and hopefully, more of a partnership to make the resource base available for use by the American consumer.

Let me talk a little bit more about how the American government can begin to respond like governments around the world to partner with this industry and provide these critical products for our consumers.

First, you must understand that the American industry has changed. Companies doing exploration and production in the United States either are or operate like independent producers. They have small staffs and little overhead, but this industry employs

people with high technology skills and pays 30 percent above the national average, the kind of jobs we need in America.

These companies are very capital-intensive and always capital-poor. Government policy impacting resource development, whether it be public lands policy, environmental, trade, or tax policy, must reflect this sea change that has occurred in this industry.

The Administration and Congress have taken a few steps in that direction of a partnership by lifting of the export ban on A&S crude and reduction on royalties of heavy oil.

Let me conclude by listing some of the policy changes that also could occur if the American government were to partner with this smaller, high-tech industry. Some of those things include removing tax penalties for exploration, technology, and improved oil and gas recovery. For example, this presentation has focused on the fact that the new technology is what is allowing us to keep our edge, yet it is unclear whether the use of technology such as 3D seismic can be expensed.

We need to increase access to public lands by reforming the Federal royalty program. One of the questions asked earlier was how much of production is on Federal lands. Over 30 percent of the natural gas production in this country is on public lands.

Let us also partner together to reduce regulatory costs, not increase them. Correct the Oil Pollution Act of 1990; with independents playing an increasingly dominant role in the offshore, it is critical that this legislation be clarified.

Finally, provide a limited antitrust exemption so that independent producers can form together natural gas marketing cooperatives and better compete in this complex natural gas marketplace.

There is tremendous promise of oil and gas in America. With the American government as a partner as is the case everywhere else in the world, the American producer, the best and the brightest entrepreneur, can tap that promise.

Thank you so much for allowing us to testify.

[Statement of Denise Bode may be found at end of hearing.]

Mr. CALVERT. Thank you. Dr. Baie, for the record, could you just briefly describe your qualifications to testify about national oil and gas estimates?

Mr. BAIE. Yes. My own background, I hold a Ph.D. in geological oceanography or marine geology for some people. I have worked in the industry for 26 years, primarily with either majors or independents on both sides. I currently am employed by an independent company. I have worked in research also.

Mr. CALVERT. Ever since the discovery of oil and gas, there have been a number of credible projections that predict that we are running out of oil, and a later witness will testify that the United States is nearly through its oil-producing era, and there is not a whole lot of oil to be found here in the United States.

Could you comment on the value of resource estimates to policymakers such as ourselves, and explain how we should use them, and do you believe that we are running out of oil?

Mr. BAIE. I will take the second one first. No, I don't. I think that the ingenuity of the people who work in our industry have shown time and time again that given the proper incentives and opportu-

nities and access to places where hydrocarbons are reservoired, that we can both find them and produce them economically.

I think one of the problems with resource estimates is, of course, they are estimates. That is a fancy word for guess. We are guessing a lot of times in absence of solid data, and that makes it very difficult.

But I think one of the things that we tend to do is we tend to get maybe too many mathematical words in there that don't help us see the great potential that may exist. I, for example, like to always look at the "upside" potential.

It is nice to know that the mean or the median or the mode or all these other wonderful mathematical terms are, but as an explorationist, if I know what the "upside" is, then I can make a decision of how important it is to look at that particular area.

If you are looking at an area where the reserve range is between 5 million and 10 million barrels and the mean is 7 million, that is one thing. If you are looking at between 500 million and 600 million, that is a much different equation for an explorationist like myself.

Mr. CALVERT. Thank you. The next question is for the entire panel.

Obviously, with drilling since post-World War II at all-time lows, we cannot find enough oil or gas to replace what we are using. On the other hand, with the increase in drilling efficiencies as we just talked about, we now discover larger quantities of oil and gas per well drilled. Less drilling is required to find a given amount of oil and gas.

What level of drilling in the United States would be required to sustain our oil and gas production at current levels, first question; and what drilling effort would be required to increase our oil and gas reserves?

Mr. WEBB. Mr. Chairman, we have done—the Gas Research Institute has done some work in that area. Our own projections based on our own supply-and-demand models are that by the year 2015, and I am talking about just natural gas, in order to meet the projected demand of about 28 Tcf compared to the 21 Tcf today, we would need approximately 20,000 gas wells. That compares to about 8,000 or 9,000 wells today, so over the next 20 years, there will be a little bit more than a doubling of the number of wells which is not—with the proper policies and with the right economic incentives, that is a task that the independents primarily in this country and the major producers can do.

Ms. BODE. That is exactly the same information that we predict in our resource base study. We predicted that we would have to double the rig count which is take it basically up to 1,400 rigs in production to meet the needs that we are going to have around the turn of the century.

Mr. CALVERT. Are our oil and gas finding costs in the United States—I know the answer to this—competitive with the rest of the world?

Ms. BODE. Yes. Yes, they are, and in fact, for most cases, for independents, our finding costs are between $4 and $5 on average in the United States. For the really good independents, they are

around $2 to $3 a barrel, and in the Middle East, their finding costs, for example, are around $2 to $3 per barrel.

The Middle East is obviously the least expensive oil to find, but we are certainly competitive, particularly with the technology advances that have reduced our costs and ability to pinpoint reserves.

Mr. CALVERT. Well, thank you. Mr. Thornberry.

Mr. THORNBERRY. Thank you, Mr. Chairman. Dr. Baie, two or three years ago, I visited with several petroleum geologists in my district. They all expressed concern that government estimates of remaining reserves were understated considerably, and based on—I don't know if you got to hear the testimony we heard earlier today, are they getting better?

Mr. BAIE. Yes, I think so, and I think one of the major changes that occurred a few years ago was this orientation toward the play concept. It is the same concept that exploration has used to find hydrocarbons.

While it still is an estimate, I think we are probably—the technology is developing, and I think if we can add to the way we are doing it now by again, integrating into the process a better estimate of what may be there that we are currently not measuring because we don't have a producing example, and I think we see that in many places in the world where there is, I guess, an axiom in the business that says the biggest fields are always found early in the history of exploration in a particular basin.

That is not true. It depends on technology and access, and there are examples in many places of the world where the largest fields have been discovered just in the most recent years by the application of new technology and new ideas.

There is no reason that we can't do that here in our producing basins. Geologists have another saying that the best place to look for oil is where it already exists, and once you have that, you can go in with better technology.

Some of the new things that are going on now to me are just amazing and I have been at it for 26 years. We can now deviate a well from a surface location, kick it five miles from that surface location to encounter a reservoir that is only 5,000 feet deep. Just amazing, and that allows us to drill from a very small footprint and develop fields in some of the areas that we are talking about that have been difficult because of environmental concerns.

Mr. THORNBERRY. And correspondingly, there is no telling what we may have in ten or 15 years, what it may allow us to see.

Mr. BAIE. Exactly.

Mr. THORNBERRY. Mr. Webb, let me ask you this. The concern that has been expressed before about natural gas is in periods of high demand whether it could be delivered where it was needed, and my understanding was, this past winter, which was relatively cold, everything went very smoothly and gas was delivered where it was needed, and there were no shortages and so forth.

Is that your understanding and has the industry matured in that sense?

Mr. WEBB. Your understanding is the same as mine is, that there were no major deliverability problems. The industry, with deregulation and the competitive pressures worldwide, have gotten a whole lot more efficient.

There is a lot more of what we call market-based storage now that de-bottlenecks, if you would, some of the earlier constraints.

In the last eight or ten years, there has been quite a bit of new pipeline capacity added, primarily to the marketing regions so that we have better deliverability.

You now have marketers and other entrepreneurs in the process and they will find a way to get you the gas if you are willing to pay for it, by letting the market work.

What happened this last year, you read, I know, in a few cases probably where the spot market hit $25 or $30. That is people that are out-of-balance. They are taking more gas than they are delivering. They have a requirement to balance, so they are willing to pay whatever it takes to avoid the penalty of not balancing. Economics works, and it was a very good year from a standpoint of nearly all-time through-put, and like you say, a much colder than normal winter, at least on the east coast.

Mr. THORNBERRY. Thank you. Ms. Bode, I guess one of the concerns I have, it seems to me the testimony that we have heard today is pretty overwhelming that we have lots of reserves left, and my concern is whether we are going to be able to take advantage of them.

I don't have any question about our technological ability to take advantage of them. I have a question about the economics of it and whether these—we heard that we have lost 500,000 jobs over the past few years. Are these people going to be able to continue to be in business, and are they going to have the capital needed to take advantage of 3D seismic and the other things? And you agree that we have to double our rig count.

I guess what I am wondering is, you list three or four things here that the Federal Government needs to do that will help. Is this going to get it done, the things you listed? Are they going to enable our domestic producers to double their rig count which is what we need to do to head in the right direction?

Ms. BODE. Well, I think that is a very good question. What we have tried to provide in the testimony was an outline of what needed to be done. As I told you, it is incredibly important to have these hearings to talk about how this industry has changed, and what government, both in the Administration and Congress needs to understand about this new industry, because so many things need to be changed from the way we are regulated to our tax policy, and this understanding is critical in making those changes, because it is a smaller, more compact, lean, mean industry, and much of the regulation was built on big companies with lots of staff and with lots of ability to access capital markets.

The majority—40 percent of the natural gas production in this country is from small, privately held producers with less than ten to 15 employees. Forty percent, so we have to figure out ways to access, to remove tax barriers—not even looking at tax credits, although that would obviously increase drilling and production in the country, but removing barriers and tax penalties.

This new technology, like the three-dimensional seismic, it is unclear under the tax code whether we can even write-off the use of that, yet it may be up to as much as 70 percent of the cost of drill-

ing a new well, and many of the new investors in this business are saying we want to see your seismic before we agree to invest in it.

We can't access the capital market, because many of our companies, almost 70 percent of the companies are privately held, not even publicly traded companies, so they have to get private investors to come in and invest, and as much as 80 percent of the capital that these private companies get is from one oil and gas investing in another, so they don't even have outside money coming in as much as they need.

So much of it is understanding the kind of industry you are dealing with and then looking across the board at a whole series of policies, whether it be trade policy or tax policy or environmental regulation, and again, we are not asking for regulation to be lifted. We are just asking for it to make sense, to be cost-effective in doing the things that we need to do and for the public lands policy to be cost-effective and to make sense and to be streamlined for these very, very small companies so that they can get to the marketplace.

They are afraid of doing business on Federal lands, because the rules are very complex and particularly for the gas producers who don't understand how come they have to pay these royalties up front before they ever get paid for it. It is just very confusing and frightening for these companies.

An understanding is critical, and that is why these hearings have been so important.

Mr. THORNBERRY. Mr. Chairman, I have one final small question.

That is an interesting point to me, coming from a state with no public lands, basically. It is not a point I have appreciated.

From an independent perspective, how important is our public land policy toward helping encourage this exploration and so forth?

Ms. BODE. It is particularly critical for us, because we are the gas producers in the United States, not big, major integrated companies, although they play an important role. It is the independent producer, as I said, these small companies, and 30 percent-plus of the natural gas produced in this country is on public lands offshore and on-shore, so we have to be able to access that in an efficient, streamlined manner, so the government's rules and regulations need to be as modern as the industry.

Mr. THORNBERRY. The Republic of Texas has some advantages that some of the states in the west don't have.

Mr. CALVERT. I want to thank you for your testimony and helping enlighten us on what is occurring in the industry, and we look forward to hearing from you again sometime in the future. Thank you very much.

The next panel that we have before us, Ms. Anna Aurilio, U.S. Public Interest Research Group; and Dr. James MacKenzie, Senior Associate, World Resources Institute.

Ms. Aurilio, you may begin any time you would like. Thank you.

STATEMENT OF ANNA AURILIO, STAFF SCIENTIST, U.S. PUBLIC INTEREST RESEARCH GROUP

Ms. AURILIO. Thank you, Mr. Chairman. I am Anna Aurilio, Staff Scientist for the U.S. Public Interest Research Group. We are the national lobbying office for the state PIRGs, which are nonprofit,

nonpartisan, active in about 30 states. We work on environmental, consumer, and good government reform issues.

I am here to testify about Federal energy policy as regards oil and gas and just to give you PIRG's perspective on this issue, because energy use and production is the largest source of pollution, and because inefficient energy use costs consumers money. U.S. PIRG and PIRGs around the country have been working to shift Federal energy priorities toward energy efficiency and clean, renewable energy sources such as solar, wind, and geothermal, away from fossil energy and nuclear power.

Americans overwhelmingly favor a shift toward clean and efficient energy resources as well. The state PIRGs which comprise our board have been working long and hard to prevent pollution, and as an environmental engineer, I know that it is a lot easier to prevent messes than to clean them up. That is another reasons that we favor the shift toward clean and efficient energy use.

Furthermore, we have been working to prevent oil drilling in our most sensitive ecological areas, particularly off the coasts of California and Florida. We have also been working nationally to stop oil and gas exploration and drilling in the Arctic National Wildlife Refuge. We believe this is a precious national treasure and should not be sacrificed. Finally, we are very concerned about our reliance on imported oil and the economic drain caused by this.

We believe that our greatest source of domestic oil lies in drilling under Detroit in increasing fuel economy of cars and light trucks.

We also would like to cite and we have cited extensively through our testimony a poll conducted of 1,000 voters by a Republican pollster, Vince Breglio, on various energy issues, and I can make a copy available to the subcommittee.

Basically, this poll showed that 95 percent of those polled strongly or somewhat favored raising fuel economy for cars and light trucks, and it was a bipartisan poll.

We also believe that the domestic oil and gas industry should look to increasing the efficiency of its own operations both in terms of energy use and oil waste rather than continuing to fight to drill in environmentally sensitive areas.

Finally, we have been working a lot, and I may have even talked to you specifically, about our efforts to cut Federal spending on programs which we believe are wasteful and harm the environment, and we think subsidies to the oil industry should be phased out since they fit this bill.

So first, why are we concerned about fossil fuels? We believe that all aspects of oil production use and refining have grave environmental and public health consequences. Over 100 million Americans live in places that have unhealthy air. Oil burning, particularly for transportation is a major cause of smog-producing chemicals in these areas.

In terms of oil drilling and oil refining, oil refining is a major source of chemical releases which are reported under the toxic release inventory. As you heard a previous speaker say, the drillers are not required to report their releases under that, but I am sure that would make a significant impact as well. In fact, as someone who works on all aspects of energy, I was astounded to find out that oil drilling operations can sometimes be allowed to release as

much radioactivity as is permitted to be released by nuclear power plants.

Also finally, increased reliance on fossil fuels threatens our global environment. The international panel on global climate change has stepped up its warning of continuing to release carbon dioxide into the atmosphere. The threat of increased storm damages has alarmed the insurance industry, not always seen as the most aggressive environmentally but an industry which has been hit very hard by increased storms in the last several years.

Finally, there is increasing concern around the public health community and the medical community about the potential for rise in tropical infectious diseases if our global climate is to change the way many scientists believe it will.

Second, our current wasteful energy practices have led to increased reliance on imported oil and a drain on our economy. According to a group called the American Council for an Energy-Efficient Economy, they estimate that national employment in 1992 would have increased by about 475,000 jobs, perhaps similar to the people that have lost their jobs in the oil industry, had the U.S. taken steps to increase energy efficiency.

So what can we do? We have long supported energy efficiency measures. Some of these same groups that I have cited in my testimony believe that if the Federal Government invests significant resources in energy efficiency and renewable energy programs, we can increase our employment rates by a net of 1 million jobs while decreasing total energy use per unit of economic output by 30 percent.

This isn't pie-in-the-sky. This is what actually has happened over the past 20 years or so. We actually increased our gross domestic product and kept energy use flat, primarily from increasing fuel economy standards for light trucks.

I would be happy to answer any questions.

[Statement of Anna Aurilio may be found at end of hearing.]

Mr. CALVERT. Thank you. Dr. MacKenzie.

STATEMENT OF JAMES J. MacKENZIE, Ph.D., SENIOR ASSOCIATE, WORLD RESOURCES INSTITUTE

Mr. MACKENZIE. Thank you, Mr. Chairman, for the invitation to appear here today. My name is James MacKenzie. I am a Senior Associate at the World Resources Institute which is a nonprofit, nonpartisan policy research center here in Washington. I am a mathematical physicist by training and have been working in energy and environmental issues for the past 25 years.

I have just completed a peer review paper that was reviewed by 12 outside reviewers, including four oil companies, on the prospects for global oil production. Mr. Chairman, I must say, I agree with much of what you have observed today about the prospects for perhaps having problems early in the next century. This is exactly what I have found in my study, and there are other studies as well that confirm this.

The type of approach that I have taken is very simple mathematically. Most of the work was done by the oil companies who have made estimates of ultimately recoverable oil over the past four decades. That is the input into a very simple, bell-shaped

curve with which I have worked, so one doesn't have to be necessarily a geologist to understand the dynamics of what is going on.

M. King Hubbert, in 1956, worked for Shell and simply asked his colleagues how much oil is going to be recovered from the lower 48 states, and it ranged from 150 billion to 200 billion barrels. He put that area under a curve, because oil production goes up and comes down. He said, well, it looks like 1965 to 1970, and 1970 was when production of the lower 48 started to decline and has basically been going down within ten percent of his curve for 40 years. Production has followed it very carefully. I have kept up these data and they are included in my report which I provided for the committee.

I have done the same thing for Alaska. It looks like about 15 billion barrels will be produced in Alaska or about 85 percent of the way through there.

The U.S. is the most explored real estate in the world. Eighty percent of all the oil wells drilled on this planet have been drilled in this country. Two-thirds of all the producing wells have been drilled in this country.

It is unlikely that we are going to find huge new amounts of oil, and I think this is the basic thrust of what you have heard here today. It will be nickel-and-diming small fields, trying to maintain production.

Higher prices in the past have not really helped. If you look at the record between the mid-'70's and the price crash and global oil prices in the mid-'80's, you find that the price of oil went from $30 to $58 per barrel, and exploration in the U.S., exploration and development wells went from 28,000 to 90,000 per year. Even so, there was a reduction in both reserves and production, so it could not be maintained.

I think that, if these curves make sense, that cumulative lower 48 production will eventually level off at around 190 billion barrels. We are about 85 percent of the way there, and Alaska, excluding ANWR, we are about 85 percent of the way through there.

What I wanted to do was to look at what the global prospect is, and in this case, I went and looked at about 40 estimates made over the past few decades of ultimate recoverable oil. I found a remarkable consistency among these that this number is someplace between 1.8 trillion and 2.2 trillion barrels. Some were a iittle bit higher. The U.S. Geological Survey comes in at 2.3 trillion; OPEC comes in at 2.1 trillion; others come in at around 1.8 trillion, and what I did was simply take the past history of production and place it under four or five different curves representing these potentials.

It turns out that the year of peaking in global oil is very insensitive to this amount. If it is at the low end, production will peak probably around the year 2005, and if you get up to 2.4 trillion or 2.5 trillion or 2.6 trillion, you would get no more than a decade more, and this result is very robust.

It would take huge amounts of oil and most of the geologists that I have spoken with believe that the world has basically been explored through all the technology you have heard today, 3D seismic and so forth. There are no more giant fields.

Even the three fields that we think of as associated with new finds, Alaska, the North Sea, and Mexico, all occurred before the

price rises of the early '70's, so they cannot be attributed to the price rises after the first embargo.

I address other questions in my paper. I clearly do not have enough time to go into them at this point.

I think that the answer to this is going to have to be a process of gradually withdrawing our dependency on oil. Otherwise, we are going to be up to 70 percent dependency, 60 to 70 percent by the year 2010. I believe there will be a tightening of supply, and in my paper, I give the evidence for this from the International Energy Agency's recent annual report, and the Congressional Research Analysis. They show that there is going to be a shortfall by the year 2005, a major shortfall globally.

If demand continues to grow at two percent per year, at 90 million barrels a day, we are not going to make it. Prices are going to rise. The U.S. with its heavy dependency on automobiles is going to be the first one to suffer.

It is imperative that we start developing alternative energy sources that can take up the slack and that can also deal with our commitments under the global climate convention.

Thank you, Mr. Chairman.

[Statement of James J. MacKenzie may be found at end of hearing.]

Mr. CALVERT. Thank you. As you may know, I am from southern California, more specifically, Riverside, California, which has a little bit of an air quality problem. Outside of Mexico City, I think we are numero uno and we have had that dubious distinction of air quality problems. We are also the home of the South Coast Air Quality Board. We are also the home of the SECERT program, the University of California at Riverside which is the center for environmental technology.

We are also, Riverside County and Imperial County, the home of the first real major geothermal research done in the continental lower 48 United States. We are also the largest wind production area in the Banning Pass, right before you leave Riverside and go on to Palm Springs, what we call the windmill thrill of Riverside County.

We also have probably the solar—out in San Bernardino County, the largest solar experiment that was done by interests in F.I. Arco in the 1970's, and so I would say, as a saving of a significant amount of money and continuing, because I know some of the people who are involved in some of these alternate energy sources and have worked with them, not just the three that I just mentioned, but on some other innovative ideas that they are coming up with, because they believe there is money in it.

I have always found that where there is money, there are people who are exploring ways to exploit that new technology, so not all hope is lost, and as we found today, as I understand what Harry Truman said, he is looking for a one-armed economist because we can always get different opinions on what is occurring.

We certainly have that on oil production. One thing that you have mentioned in your testimony on phase-out of oil and gas subsidies, the deepwater provision that just passed this House and was signed by the President and supported by this Administration, CBO scored that as a positive dollar provision, not as a negative.

Is your lack of support for deepwater based on dollars or is it based upon a philosophical position not to create incentives to have oil production off the coast of the United States?

Ms. AURILIO. I believe actually that the question that was raised about CBO, and I believe there were two different estimates. One was a Department of Energy estimate, and I think it was the first time that I saw Congress support Hazel O'Leary during all the inquiries about her travel, was on the Floor that time, that showed it was a net revenue raiser.

CBO's estimate over the long-term shows that it is actually a money loser, and I have a letter in my files from them that shows that it is.

Mr. CALVERT. They re-evaluated that and they discovered that it wasn't. However, as with all economists, there are those who have different projections on whether it is a loser or not, but certainly, as far as our budget projections are concerned, in this world, we live and die by the budget.

It is a net revenue gain, and there are two different ways of looking at whether it has long-term projection or not.

However, I do agree that we should continue to look at alternative energy sources. I am supportive of that and have been and continue to be, and certainly, being from southern California, can't help but be.

At the same time to recognize the predominance of energy use in the United States presently is oil and gas and the reliance on that is going to be continuing. However, if there is anything other than an insurance policy, we should continue to explore alternative uses and obviously, for environmental reasons, too, and I can say that from my own experience.

Those things are happening, maybe not as fast as some people would like them to happen.

Any other comment?

Ms. AURILIO. In terms of the quickness, that is precisely why we advocate a shift in Federal energy priorities. The oil and gas industries have benefited from a history of Federal subsidies and intervention, and we believe that the renewable energy industries and energy efficiency programs need to get that same kind of benefit in a time of scarce Federal dollars.

You can either choose to fund energy efficiency programs, for instance, there is the low income weatherization program that I always like to use as an example. This is one that saves actually many barrels of oil, because a lot of it goes to the northeast where people use oil for actually heating their homes. It helps these low income people become more financially independent, because they are not spending their disposable income on their energy bills. Instead, there is the old adage about teaching someone to fish. It helps them weatherize their homes, so that is a very cost-effective and environmentally sensitive program that we think should be supported. On the flip side, that is competing with some of the fossil energy programs that DOE continues to fund, so it is a question——

Mr. CALVERT. DOE is also—interesting, I used to work for a physicist who used to be a member of this body. Graduated from Cal Tech and still a close friend of mine, and was very much in-

volved and still has great hopes for fusion and hydrogen and some other types of energy uses that are somewhat controversial.

This Congress and this government has funded research for fusion. My colleague in the House, George Brown, who is also a physicist, has great support for fusion. Also, my friend at the University of California who is actually a chemist by background but considers himself an amateur physicist, I guess, has great hope for the prospect of fusion.

Mr. MACKENZIE. Not in my lifetime.

Mr. CALVERT. Not in your lifetime. You don't——

Mr. MACKENZIE. I think that hydrogen—I am on the hydrogen advisory panel to the Department of Energy and I think that hydrogen made from renewables, stored in hydrides or some other way with fuel cell vehicles will be a much easier way than having a machine with 100 million degrees inside it, and it is going to take the Princeton faculty to run it. It is just unlikely to be——

Mr. CALVERT. Pretty expensive, too. I don't disagree with that, but I just wanted your feeling about it.

Mr. MACKENZIE. There are a few——

Mr. CALVERT. We are still funding it to a large degree.

Thank you very much for your testimony. I appreciate your coming today.

[Whereupon, at 5:30 p.m., the subcommittee was adjourned; and the following was submitted for the record.]

Testimony of

C. Kyle Simpson

Associate Deputy Secretary for Energy Programs

U.S. Department of Energy

Before the

House Resources Committee

Subcommittee on Energy and Mineral Resources

U.S. House of Representatives

March 21, 1996

Washington, D. C.

Mr. Chairman, and Members of this Subcommittee, it is a pleasure to be here today to discuss our Nation's natural gas and oil policies, and, specifically, the positive impact the Administration's Domestic Natural Gas and Oil Initiative (DNGOI) has had on our natural gas and oil production. This is an appropriate opportunity to discuss our accomplishments, share our disappointments, and lay out the challenges and opportunities ahead.

We believe that our achievements are substantial. They are particularly noteworthy at a time when energy issues have faded from public view due to recent low energy prices, and the easing of the public's energy security concerns following the successful conclusion of Operation Desert Storm. Legislation, championed by the Department of Energy (DOE) and spearheaded by a crucial DOE study, has released Alaska North Slope oil from the regulatory shackles imposed 23 years ago. Alaska and California stand to benefit in particular, and the country as a whole gains as well.

The Administration has worked tirelessly to support royalty relief legislation that will bring more of our domestic resources within economic reach in the deep water of the Central and Western Gulf of Mexico. We continue to marshal the resources of the public and the private sector with the Computational Technology Forum, a program with low startup costs and nearly immediate benefits. And we continue our unwavering efforts to facilitate the deployment of advanced technology, lowering production costs and improving the environment, in our successful onshore Class Program.

But we have suffered our share of disappointments as well. The inappropriate financial responsibility amounts of The Oil Pollution Act of 1990 or OPA 90 have yet to be successfully resolved despite intense efforts by the Administration and the National Petroleum Council. And budget cuts to successful programs, whose benefits are far in excess of their costs, continue to frustrate our efforts to build a stronger domestic industry, to move to a cleaner environment, and to create a safer, more secure energy future.

The Administration's energy policy is based upon two decades of experience in dealing with energy issues. We learned that price and allocation controls did not work for us in the 1970s any better than they worked for the old Soviet Union. We learned that big ticket, large project development often is not the best approach toward building a balanced portfolio of energy investments. Most importantly, we learned that lurching from policy to policy in the wake of successive crises, trying to change overnight the way people live, work, travel, and invest, is expensive and counterproductive. Instead, a steady, sensible, policy approach seeking long-term, cost-effective results, and relying on markets, is the one we are taking.

As a cornerstone of our energy policy, we must have a healthy, robust and efficient domestic natural gas and oil industry. This Administration believes the availability of reliable sources of affordable energy, and the efficient utilization of energy, are, and will remain for the foreseeable future, critical for our Nation's economic strength, environmental quality, and national security.

That is why the Department of Energy supports an extensive number of well-structured, sharply focused energy policy initiatives and research and development (R&D) programs that enable us to sensibly diversify our portfolio of energy resources, improve our environment , and increase our ability to respond more deftly to changing circumstances that may include energy price shocks caused by sudden supply disruptions in the global oil market.

The fact that the United States consumes nearly $500 billion of energy a year -- about 8 percent of its Gross Domestic Product -- helps place our public R&D investment of less than one-third of one percent of our consumption in the proper context.

In June 1995, the Secretary's Task Force on Strategic Energy Research and Development, a panel of independent energy experts chaired by Daniel Yergin, found that DOE's energy R&D funding had been reduced in constant dollars by 75 percent over the past 17 years. Moreover, many believe private sector energy R&D is also being scaled back and is shifting away from research with long and mid-term goals. However, funding reductions in many areas are being offset by collaborations and cooperative ventures in the private sector. Despite benefits to their long-term competitiveness, increasingly competitive global markets are causing U.S. businesses to be more reluctant to perform energy research where returns are unlikely to be realized in the short term. Further reductions in energy R&D threaten the adequacy of the nation's energy supplies and its environmental quality into the next century.

The Department of Energy's R&D programs -- designed in concert with industry to supplement and improve the productivity of private sector R&D investments -- are a part of the Nation's portfolio of investments in our future. Our work covers a broad spectrum of energy forms and technologies intended to make the production and utilization of all forms of energy more efficient and environmentally benign.

The United States is reliant on fossil fuels for about 85 percent of its energy. Given current fossil fuel prices and present understanding of domestic and world oil resources, many experts forecast that relatively low fossil fuel prices will continue into the near future. Currently, natural gas and oil collectively represent 63 percent of our energy usage. Our policy and R&D efforts in fossil fuels are aimed at driving down the costs of finding and developing these resources while maximizing the economic, environmental and national security benefits of increased usage of natural gas and other traditional fuels. These actions contribute to our energy security, while increasing the flexibility, or price elasticity, of our energy supply and demand. The technical advances that flow from our collaborative R&D efforts with the U.S. energy sector create a stream of future benefits that enhance the private sector's long-term economic growth and productivity.

Focusing more specifically on the industries under discussion here today, the overall health of the U.S. natural gas and oil industry depends in large measure on two variables: the price of oil and gas, and the cost of its production and delivery to the market. Both oil and gas prices remain volatile and significantly lower than the historic highs of the early 1980s. Oil prices are expected to stay weak with the prospect of Iraq's limited reentry into an already

adequately supplied global oil market. The long-term outlook, however, is for natural gas and oil prices to stabilize, which should allow for adequate returns on investment provided the energy industry can continue to drive its production costs down.

Oil and gas prices are established in an open and free market environment, consistent with this Administration's strong stance on free trade. Therefore, while our government has virtually no control over world oil prices or domestic natural gas prices, we can and do, in fact, play an important role by helping U.S. producers lower their costs of production through collaboration on the development and deployment of advanced technology, and by reducing regulatory burdens.

Although some voices urge additional tax incentives as the route to a healthier energy sector, this Administration and this Congress are firmly committed to reducing the deficit and balancing the budget, making the prospect of enacting additional tax incentives highly unlikely.

We believe a more productive path is to follow a steady, sensible approach, seeking long term, cost-effective results through policy initiatives and leveraged investments in exploration, production and processing technologies -- such as those pursued under the umbrella of the Domestic Natural Gas and Oil Initiative in the areas of technology and R&D, regulatory relief, and efforts to displace oil with increased domestic natural gas usage. Our policies and programs are designed to lower the cost of production with technological advancements and the re-invention or removal of costly, duplicative and time consuming regulatory requirements. We have also worked to remove impediments and allow production from those federal lands where it has been determined that production is in the national interest. The Department has designed its budgetary priorities with these essential national goals in mind: satisfying the nation's energy needs, reducing our vulnerability to oil supply disruptions, protecting the environment, and improving the economy. A chart is included with this testimony that updates progress in implementing the Domestic Natural Gas and Oil Initiative.

The Administration's goals are to collaborate with the natural gas and oil industry to reduce the cost of its operations through policy initiatives that remove market barriers, reduce the cost and time required for regulatory compliance, and provide new opportunities through jointly-funded, industry-driven R&D programs that develop advanced and cost-effective exploration, production, processing, and environmental compliance technologies.

At the Department of Energy, we are working specifically to stimulate sustainable development and utilization of the nation's natural gas and oil resources and technologies to assure an ample, secure, clean and low cost supply of energy. Our work will be done in a way that will help to assure U.S. global leadership in oil and gas technology; protect the local, regional and global environment; merit public trust; promote public-private partnerships; create U.S. jobs; and contribute to a stronger economy.

As a next step, Energy Secretary Hazel O'Leary asked the National Petroleum Council to prepare a report on the future of the industry. On August 9, 1995, the Council submitted to

the Secretary its report, "Future Issues-A View of U.S. Oil and Natural Gas to 2020". The report analyzed the oil and gas industry's role in the nation's economy, identified the issues and policies that will most likely shape the industry over the next 25 years, and provided approaches to resolution of those issues. Secretary O'Leary has established an inter-agency working group to address the issues identified by the Council.

A. Natural Gas and Oil Supply and Processing R&D

Advances in supply and processing technology lower production costs, expand our resource base, improve process reliability, and help meet environmental requirements. An example of technology's payoff is readily apparent in increased production from the Outer Continental Shelf (OCS) and onshore lands. Recognizing the critical role of technology in the gas and oil industry, this Administration, since 1992, has doubled Government R&D advanced technology investments with American industry in the exploration and production of natural gas and oil.

Our oil R&D programs may contribute to expanding resource recovery by 4 to 7 billion barrels and lift production by 600,000 to 900,000 barrels a day in 2010. Through our natural gas supply R&D programs, we are cooperating with industry to develop a new generation of technologies to reduce the costs, further ensure long-term supply and expand demand by increasing consumer confidence that affordable natural gas will be available. These efforts will help lower exploration and production costs by $290 million per year and contribute to adding nearly 2 trillion cubic feet of new gas production by the year 2010.

- Because of advanced technologies, specifically 2-D and 3-D seismic and reservoir simulation modeling, the United States Geological Survey (USGS) in 1995 estimated our onshore natural gas resource base to be twice as large as its earlier estimate in 1989. This increased resource estimates from 504 Tcf to 1074 Tcf.

- Gas and oil resources are projected by the independent Energy Information Administration (EIA) to expand at an average annual rate of 2 to 3 percent (in terms of constant 1994 dollars) and drilling costs projected to decline at an average annual rate of 2 to 4 percent, depending on such factors as fuel type, location, and geological and technological maturity.

- Since 1985, natural gas production has increased by 15 percent while gas prices in real terms have declined 22 percent for residential consumers.

- Since the 1980s, industry exploration and development costs have declined over 75 percent to $4.53/barrel (1994 dollars) from $21.50/BOE enabling companies to expand their reserves at cost levels appropriate for the uncertain oil and gas price environment.

- U.S. operators in 1994 successfully discovered oil and gas with 38 percent of all exploratory wells drilled, up from 29.7 percent in 1981. The rate of success for completion of development wells increased from 80% to 82% over the same period. Federal acreage in Texas and in the Gulf of Mexico accounted for almost two thirds of total U.S. discoveries of natural gas in 1994 and 40 percent of development wells.

- In environmentally sensitive areas, advanced technologies, such as extended reach and horizontal drilling, minimize the "footprint" or land area needed for drill pads and wellhead support.

If such improvements are to continue, however, much will depend on the rate of future technological development. Progress is incremental in terms of improvements because of the increasing complexity of the necessary energy R&D technologies and their life cycle -- the typical time span is about 15 to 20 years from the scientist's bench to the product's commercialization. In other industries, such as biomedical, consumer products, aerospace, and electronics, the R&D life cycle is a considerably shorter 5 to 15 year period.

Our natural gas and oil R&D program is an industry-driven, balanced portfolio of investments reflecting both our national energy demands and the industry's technological needs. Federal/state/industry cost-shared R&D partnerships leverage available DOE resources in an ever-changing environment. Valuable advice from stakeholders such as the 1995 National Petroleum Council's study, *R&D Needs of the Industry*, Daniel Yergin's report, *Energy R&D: Shaping our Nation's Future in a Competitive World*, and from the Petroleum Technology Transfer Council's R&D workshops, enable us to sharply focus our R&D programs.

Our collaboration with industry has produced numerous important technological advancements in the drilling and production area, including:

- Interactive Satellite Communications: A new Department of Energy project with the American Petroleum Institute (API) involves DOE's Sandia and Lawrence Livermore National Laboratories in the high speed tranfer via satellite of large amounts of seismic data collected during offshore oil and gas explorations to land-based research facilities. Dubbed AIRES, which stands for Asynchronous Transfer Mode Research and Industrial Enterprise Study, the project uses a NASA-launched satellite which orbits 22,300 miles above the earth. API President, Charles DiBona, predicts this technology will "revolutionize" the process of energy exploration and production and "will permit us to do in a few minutes what normally might take weeks, or even months. It's been estimated that the reduced time for completing seismic surveys could save more than $200,000 per month, per survey."

- Polycrystalline Diamond Bits: When drilling in specific rock types, on an

offshore well, for instance, producers can save as much as $1 million per well depending on depth. Thirteen companies worldwide now fabricate synthetic diamond bits, with U.S. companies producing about 4000 bits yearly worth $200 million.

- Radial Offshoot Holes For Heavy Oil Production: A basic problem for operators injecting steam into heavy oil fields is their tendency to override and bypass the oil-bearing zone. DOE-sponsored tests with Petrolphysics, using an ultra short radius radial system, have significantly increased production from heavy oil reservoirs in California. This advanced technology has doubled the thermal efficiency of steam utilization and saved producers $200,000 per well, compared to drilling a horizontal well.

- Hot Oiling Paraffin Treatment: The buildup of paraffin in the wellbore and near-wellbore formation can cause severe production decline of waxy crudes and result in lift equipment failures. Sandia National Laboratories, working with Petrolite Corporation, developed a computer model that optimizes paraffin treatment. This new software enables both service companies and independent producers to drive down operating costs. Industry-wide use of this software could reduce well abandonments and result in more than $150 million in yearly savings.

The Department has also been able to use the talent in our national security laboratories to assist our nation's oil and gas industry. A key strategic alliance with industry that includes DOE's National Laboratories and major universities is the Natural Gas and Oil Partnership program. Within that program, our Computational Technology Forum is designed to take the Laboratories' cutting-edge, world-class computational and modeling skills developed for defense purposes, and shift them to private sector energy research applications to aid in the search for new resources and optimize extraction from existing reservoirs. Processing massive amounts of seismic and 3-dimensional simulation data require ultra high speed processors and new algorithms that have not been readily available to the oil and gas industry in the past. Through a competitive solicitation, an industry panel reviewed and selected 31 cooperative projects, each involving one or more service companies. Industry contributed 58 percent, or $38 million, of this $65 million program. Two thirds of these projects are in the advanced seismic research area. For example, the DeepStar Consortium, a group led by Texaco whose membership includes 19 producing companies, 40 service companies, and several consultants, is developing advanced computational models for deep water oil and gas production in highly promising areas in the Gulf of Mexico. Because this innovative government/industry forum has been so successful, it is all the more disappointing that the Congress has eliminated FY 1996 funding for the Advanced Computational Technology Initiative in the Interior Appropriation Bill, cutting short its Phase I projects and eliminating its follow-on Phase II solicitation. These cuts will prevent many domestic oil and gas producers from fully capitalizing on the enormous investment made by the Federal Government in advanced computing technology. We are asking Congress to provide $8 million for this work in fiscal year 1997.

Another successful partnership whose funding is in doubt this year is the Oil Reservoir Class Program. Given the constrained budget for oil and gas R&D, the Administration has decided not to pursue funding for the program beyond Classes 1 through 3. This demonstration program was designed to utilize advanced reservoir characterization techniques that can extend the economic life of domestic reservoirs in danger of premature abandonment. Thirty three projects, totaling $295 million, involving teams of producers, service companies, and universities were selected to develop and transfer technologies to other producers. All of these projects demonstrate that advanced technologies can indeed prolong the economic life of some of our nation's commercially-marginal oil resources. As much as 4 billion barrels of potentially recoverable crude oil in these fields are likely to be permanently abandoned if this program is canceled. From projects underway, domestic companies, many of them smaller independents, have begun to increase production from fields that were on the verge of abandonment. The impact of these programs is real, not theoretical. The United States can ill-afford to turn its back on oil resources that, with advanced technology, could potentially be produced. The Department's R&D partnered with industry could preserve the viability of these resources and increase domestic production by nearly one million barrels per day by 2015, offsetting equivalent amounts of imported oil.

Examples of these threatened projects include:

- Texaco's Class I project is demonstrating the application of CO2 flooding using horizontal injection wells for improved recovery in watered-out salt dome reservoirs in southeastern Texas. Although only 18 months into the project, production has increased by nearly 400 barrels per day.

- DOE, working with Lomax Exploration, has demonstrated that advanced reservoir imaging technologies, applied in oil basins whose complex geology makes recovery difficult, could be used to pinpoint formerly undetected compartments and to economically produce previously unrecoverable oil. DOE's share of this project was $1.8 million with Lomax contributing $2.8 million. The Lomax project which is on federal land will result in the production of an additional 2.4 million barrels of oil. Using this new technology, 11 additional waterfloods will be undertaken in neighboring fields by the private sector. This effort alone is expected to generate an additional 31 million barrels of oil -- resulting in more than half a billion dollars in direct revenues and additional tax and royalty payments larger than the cost of the entire Reservoir Class program. Since these 11 projects cover only 13 percent of the area, reserves could easily double or triple.

It is absolutely critical that our government continue to foster technological innovation that keeps our U.S. energy industry competitive. Dr. Marcus Milling of the American Geological Institute, a federation that represents more than 80,000 geologists and geophysicsts, underscored this point when he recently testified that

"DOE's fossil energy R&D programs are making significant contributions to the development of new technologies required for cost-effective, efficient development of U.S. oil and gas resources. Reductions in the program would adversely affect the domestic oil and gas industry, particularly small independent producers, and would not be in the best interests of the nation. The federal money spent on these programs goes to support laboratories and improve information dissemination. This money does not go into corporate coffers, but it will help American businesses stay in business by giving them a technological edge over their foreign competitors."

B. REGULATORY RELIEF

Alaska North Slope (ANS) Exports

In 1993, DOE pledged in its Domestic Natural Gas and Oil Initiative to evaluate lifting the ban on ANS crude oil exports to contribute to greater energy production and economic growth. That study, completed at mid-1994, became the basis for the Administration's initiative resulting in legislation to remove the restriction. We would be remiss, Mr. Chairman, if we did not salute you and your colleagues on this Committee for your strong leadership on this important measure. It was "a job well done" when S.395 was signed by President Clinton on November 28, 1995. That Act allows four months for an environmental review, plus another month to complete a presidential national interest determination. The Commerce Department, as the export licensing agency, now has the lead on both issues.

Hearings were held in Washington, D.C., Seattle and Anchorage in early February, 1996 to obtain public comment on the economic and environmental impacts. The interagency study team is now completing its analysis and preparing documentation of the economic and environmental review which the President is expected to send to Congress by the end of this month. This Administration initiative will mean as many as 25,000 more jobs for American workers, particularly in California and Alaska. It will reduce the decline in domestic production by roughly 100,000 barrels per day and boost international trade. The process will be completed by the end of next month.

Royalty relief

The Administration is cutting red tape and streamlining regulations to provide royalty relief for oil and gas wells on Federal onshore lands. The Department of the Interior, with the active support of the Department of Energy, has already instituted royalty relief for marginal oil wells and heavy oil, and is in the process of developing similar relief for marginal gas wells. The Interior Department has also changed its leasing policies and royalty rate structures governing oil and gas properties on the Federal Outer Continental Shelf (OCS) to provide incentives to extend the production from marginal wells and to develop new projects in deep waters.

Last year, the President signed into law the bill to provide royalty relief to deep water production on the Outer Continental Shelf in the Central and Western Gulf of Mexico. For new leases, royalty relief will apply to all lease sales in the Central and Western Gulf between 1996 and 2000. Royalty relief on existing leases will be permitted to the extent that the leaseholder can demonstrate that production would not occur without the relief.

With regard to heavy oil relief, DOE through our reservoir modeling capabilities actively supported the Department of the Interior's move to institute reduced royalty rates for heavy oil produced on onshore Federal lands. This initiative will encourage additional production of heavy oil, particularly by California independents.

Oil Pollution Act of 1990 financial responsibility (OPA 90)

DOE has actively participated in the debate over the higher financial responsibility requirements of OPA 90, and consulted with the Coast Guard on the implementation of the Certificates of Financial Responsibility requirements. While supporting OPA's increased financial responsibility requirements for tankers -- the "polluter pays" principle -- DOE felt that OPA's financial responsibility provisions for offshore facilities were unreasonable. Secretary O'Leary commissioned a study by the National Petroleum Council and has acted on its recommendations by supporting the efforts of the industry and the Department of the Interior to develop a rational, risk-based approach to financial responsibility requirements for OCS facilities.

Bureau of Land Management National Performance Review

DOE has worked closely with BLM on the Bureau's Onshore Oil and Gas Performance Review in order to make its regulatory structure more efficient and responsive involving oil and gas recovery on public lands. With the collaborative partnership effort between DOE and BLM, the performance review is moving forward effectively to streamline regulations and identify further opportunities for improvement in oil and gas operations. DOE contributed technical and economic analysis in the areas of incentives, bonding, unfunded liability, NEPA resource planning and regulatory review.

Royalty Fairness

The Administration is working with the Congress on proposals to improve the fairness of the royalty collection process for onshore and offshore oil and gas production. The process has grown increasingly complex and contentious as changes arise in how these commodities are marketed. The Administration and Congress have made progress , however, and we will continue to work with the Congress in an attempt to resolve these issues.

C. ACCESS TO PUBLIC LANDS

Lease sales in the OCS and Five Year Plan

DOE supports the work of the Department of the Interior and its Minerals Management Service (MMS) as they promote the orderly, environmentally responsible development of the natural gas and oil resources on the Outer Continental Shelf (OCS). The success of the latest lease sale on the OCS is an example how the government and industry can work together to ensure the timely development of the Nation's offshore resources. In addition, we support the size, timing and location of leasing as described in MMS' *Proposed Leasing Program (1997-2002)*. This program continues annual sales -- on a dependable timetable to aid industry planning -- in both the Central and Western Gulf of Mexico Planning Area.

Green River Basin Initiative

DOE is providing its technical and analytical expertise as an ex-officio committee member to the Bureau of Land Management's Green River Basin Advisory Committee. This committee will make recommendations to the Secretary of the Interior as to how to best develop the oil and gas resources in the Green River Basin of Wyoming and Colorado without compromising the environment. The committee's first meeting was earlier this month and its final report is expected in a year.

Conclusion

The Administration is proud of its successes in its energy policy. We are particularly pleased with what we have been able to accomplish to reduce costs and remove regulatory barriers in the natural gas and oil industry. This Administration moved early toward establishing a framework -- the Domestic Natural Gas and Oil Initiative -- within which it could target its opportunities. Working with Congress, we have removed a barrier to the export of Alaska North Slope crude oil that has been in existence for over 23 years, and we have provided a new, important incentive by providing royalty relief on deep water production in the Central and Western Gulf of Mexico. We have cooperated with our domestic industry on a wide variety of projects, but most recently on those that can improve the use of seismic technology, which has proved so critical in reducing the cost of production and opening new sources of energy in the subsalt regions of the Gulf of Mexico. We can proudly say that after three years of work, this Administration has achieved successes that make our domestic industry healthier and more efficient.

But we also acknowledge our disappointments. We have worked hard to remedy the problems associated with the financial responsibility provisions for offshore facilities in the Oil Pollution Act of 1990. While both chambers have passed different solutions, the

Congress has yet to send forward a final resolution of the issue. Also, of great concern is the Congressional undercutting of R&D efforts that are so crucial to the future well being our nation.

We hope that in the future we can continue to work together to reduce market barriers, and find ways to improve our technology so that the U.S. retains its preeminence as the world leader in the development of oil and gas technology. Thank you, Mr. Chairman, I would be pleased to answer any questions or provide additional material for the record.

PROGRESS REPORT ON DOMESTIC N. JRAL GAS AND OIL INITIATIVE (DNGOI)

Domestic Natural Gas and Oil Initiative Actions (December 1993 Release)*	Completed	In Progress	Proposed to Congress	
			Not Acted On	Rejected (No Funding)
1.0 Promote Advancement of Technologies				
1.1 Computational Technology Forum	✓ Phase I - 31 projects			✓ Phase II
1.2 Drilling Systems (Gas)		✓		
1.3 Advanced Oil Recovery (Class Program)	✓ Classes I-III			✓ Classes IV/V
1.4 Advanced Geologic Basin Analysis		✓		
1.5 Issues of Small Producers				✓
1.6 Commercialization Strategy (Gas)	✓ Strategy published			✓ Fuel Cells
1.7 Technology Transfer Network	✓ 7 PTTC centers ✓ IEA Gas Center			
1.8 Review G&G/Other Tax Issues	✓ Analysis completed	✓ (on hold because of deficit problems)		
1.9 RMOTC (NPR) Training Site				✓ (funding substantially cut)
2.0 Environmental Technologies/Practices				
2.1 Compliance Technologies/Practices	✓	✓		
2.2 Environmental Research Coordination	✓			
2.3 DOE's Role in Oil Spill R&D		✓		
2.4 Study Used Oil Recycling		✓ Draft completed (transferred to EE)		

ANS: Alaskan North Slope; BLM/NPR: Bureau of Land Management/National Performance Review; EE: Office of Energy Efficiency and Renewable Energy; IEA: International Energy Agency; G&G: Geologic and Geophysical; NPR: Naval Petroleum Reserves; OCS: Outer Continental Shelf; OPA: Oil Pollution Act; PTTC: Petroleum Technology Transfer Council; RMOTC: Rocky Mountain Oilfield Testing Center

* Action Items 3.0 - 5.0 are not listed because this chart just focuses on R&D and Federal lands.

Domestic Natural Gas and Oil Initiative Actions (December 1993 Release)*	Completed	In Progress	Proposed to Congress	
			Not Acted On	Rejected (No Funding)
6.0 Simplify Regulations				
6.1 Streamline State/Federal Regulation	✓ Projects, BLM/NPR			
6.2 Enhance Government Decisionmaking	✓ Environmental modeling and metrics	✓		
6.3 Progress Beyond Command and Control		✓		
6.4 Enhance Dialogue Through Partnerships	✓ New outreach program	✓		
6.5 Review NPC's Report on Oil Refining		✓		
6.6 Enhance Scope of NPC	✓ Added 55 members			
7.0 Evaluate Production From Federal Lands				
7.1 Interagency Energy Coordinating Group	✓			
7.2 Naval Oil Shale Reserves		✓ Study authorized - S.1124		
7.3 Increase Production OCS Deep	✓ Bill passed			
7.4 Marginal Prospects - Gulf of Mexico (OCS)	✓ Leasing options	✓		
7.5 OPA '90 - Small Operators	✓ Work completed		✓ (need Senate action)	
8.0 Work with States/Native Americans				
8.1 Work with States - DNGOI	✓ 3 projects	✓		
8.2 Native American Tribal Lands				✓ (grant)
9.0 West Coast Production Constraints				
9.1 Open Access to California Pipelines		✓ Analysis		
9.2 Study: Lift Ban on ANS Exports	✓ Bill passed			
10.0 Study Costs/Benefits of Oil Imports		✓ (interagency review)		

24-645 - 96 - 3

TESTIMONY OF MIKE DOMBECK
ACTING DIRECTOR, BUREAU OF LAND MANAGEMENT

Before the House of Representatives' Subcommittee on Energy and Mineral Resources

Oversight Hearing on Energy Policy

March 21, 1996

Mr. Chairman, members of the subcommittee, I appreciate the opportunity to come before you today to discuss the Bureau of Land Management's oil and gas program. Over the past three years, we have made a number of significant accomplishments and have many projects and initiatives in progress which reflect our commitment to a collaborative effort when it comes to making decisions which affect our use of the public lands.

OIL AND GAS BUDGET OVERVIEW

The FY 1997 President's Budget proposes $51,800,000 for oil and gas, essentially the same as the 1996 Conference level. This level of funding will permit continuation of program activities consistent with the 1996 program.

At the end of 1995, more than 51,000 leases existed on Federal lands covering about 37 million acres. About 19,000 leases were in producing status which contained more than 63,000 producing wells on public lands. This figure is up 30% since 1985, while natural gas production has increased by 60% over the past ten years. The BLM is also responsible for operational management oversight of about 4,200 producing leases on Indian lands, supervision of drilling on non-producing leases, and advising BIA and Indian tribes and allottees on leasing matters.

The oil and gas program generates receipts from filing fees, bonuses, rentals, and royalty payments. In 1997 we expect such royalties to exceed $500 million. All receipts, except for filing

fees, are shared with the State in which the leasing occurs. These oil and gas revenues play an important role in the economies of several western States and communities.

Our leasing program will continue to be focused in those areas where the prospect for discovery is highest. We will be encouraging industry to nominate parcels while at the same time reducing the number of parcels which BLM offers on its own initiative. This approach will maximize the effectiveness of money spent in our leasing program.

The post-lease workload for the oil and gas program will remain constant. In FY 1997, we expect to process 2,300 Applications for Permit to Drill (APDs), 25,000 lease adjustments, close to 1,900 drainage cases, and conduct about 17,000 inspections.

Inspection and enforcement remains a high priority program activity. We will continue to conduct inspections of leases as required by Federal Oil and Gas Royalty Management Act, as well as conduct drilling, abandonment, and other inspections authorized under the Mineral Leasing Acts.

The 1997 proposal stresses continuity of services and additional progress toward implementing streamlined processes to produce cost savings.

OIL & GAS INITIATIVES

PERFORMANCE REVIEW

As part of the BLM's Performance Review, we have involved our customers in our decisionmaking to ensure that the BLM develops effective policies. The Performance Review has evaluated the Bureau's oil and gas operations, regulations and policies, and identified opportunities to improve the way the BLM provides services to its customers. During the first phase of the performance review, BLM developed a questionnaire and compiled the comments

and concerns of its constituents regarding the Federal oil and gas program and how it could be improved.

Reports from the performance review teams were consolidated and released a year ago. The Bureau Performance Review Final Report recommends numerous changes to the Bureau's oil and gas program. We are now implementing these recommendations and I would like to mention a few of them.

- **HEAVY OIL**

A year ago, the heavy crude oil industry was suffering from low prices and high production costs. Although rising prices have recently provided some relief, this administration recognized that producers would still be vulnerable to future price fluctuations. As many as two-thirds of the marginal properties could be shut-in during a period of sustained low oil prices. The BLM's new rule, published on February 8, 1996, establishes the conditions under which the operators of properties that produce heavy oil, crude oil with a gravity of less than 20 degrees, can obtain a reduction in the royalty rate. As a result of this action, more wells will remain in production even when oil prices are low. The Department of Energy calculates that recoverable reserves will increase significantly as a direct result of this rule. The rule will act to extend the life of the wells affected. Premature abandonment of Federal oil and gas leases will be minimized, and adverse economic and environmental impacts on State and local communities will be reduced. This rule went into effect on March 11, 1996.

- **MARGINAL GAS**

BLM has also asked the Department of Energy to assist in evaluating the effects of recently promulgated regulations which reduce the royalty rate on marginal gas production.

In 1994, more than 3,000 marginal or "Stripper" gas wells were abandoned in the United States. The Interstate Oil and Gas Compact Commission (IOGCC) estimated that abandonment of these "stripper" wells resulted in jobs lost and nearly $40 million in revenues lost to the U.S economy. Typically, marginal gas wells are abandoned because increasing costs prevent them from being profitable. However, incentives such as a royalty rate reduction may extend the economic lives of many of these wells, increasing the amount of recoverable reserves, preserving jobs and providing royalties over a longer period of time.

The BLM published a "notice of request for information" in the Federal Register (March 5, 1996) asking its customers to help define marginal gas and to suggest ways in which royalty relief might be granted by methods in addition to a rate reduction We look forward to receiving those responses by June 3, 1996 and welcome any thoughts this Committee might have

- **IMPROVING THE APPLICATION FOR PERMIT TO DRILL (APD) PROCESS**

The first action required to initiate operations on a Federal or Indian lease is the filing of an application for permit to drill (commonly referred to as an APD). FOGRMA requires that the APD must be submitted complete, must be posted and made available for public inspection for at least 30 days prior to approval action. We are aware of the need for timely processing and approval decisions on APDs.

However, problems can and do occur in the APD approval process. These problems include: weather conditions that prevent on-the-ground environmental review; failure on the part of the operator to submit a complete application; an overload resulting from large numbers of APDs being filed in an area of active development; and delays encountered when surface management agencies other than the BLM, require approval of their surface use plan prior to the

BLM approving an APD.

The BLM is evaluating the problems that make it difficult to meet its goal of timely approval of all applications. In particular, although the vast majority of APDs submitted to the BLM are reviewed and an operator receives a timely decision, in some instances the application process is taking too long. To address these concerns, BLM has formed an interagency task force (DOI, USFS, DOE) to identify obstacles and develop internal procedures that will help expedite the approval process. The APD task force is scheduled to complete its work by early June of this year.

- **TECHNOLOGY TRANSFER MOU WITH DOI AND DOE**

As we plan for the future, we must support advances in technology that allow us to fully utilize the natural resources on public lands while, at the same time, preserving the character and value of these lands for other future uses. The Bureau Performance Review encouraged these advances by advocating a comprehensive technology and information transfer program. The Department of the Interior is working with the Department of Energy to implement this recommendation and codify a long standing DOI/DOE collaborative practice through a Memorandum of Understanding (MOU). The memorandum provides easier and wider access to public information generated and maintained by Federal agencies on exploration, development and production of oil and gas on public lands. Hence, it will enhance the ability of Federal agencies, State agencies, and the private sector to resolve onshore oil and gas issues related to public lands via technology transfer and data sharing. Our experience with heavy oil and marginal gas prompt us to believe that formalizing this relationship will be beneficial to future oil and gas projects. The MOU has been signed and we are now operating under this formal agreement.

- **REINVENTING GOVERNMENT, PHASE II**

As you know, under the REGO II initiative, the BLM has proposed to consult with States and Tribes on the opportunity to transfer oil and gas inspection activities from the BLM to the State and Tribal authorities. The BLM formed a task force comprised of State, Tribal and Federal representatives who together have prepared a report on this REGO II initiative.
The report has been forwarded to the States and Tribes for their review. The transfer would include production verification and environmental compliance. The report reflects recommendations based on cost savings, funding, and availability of expertise to handle the program. The task force's final recommendation was to have each BLM State office meet with State and Tribal officials to determine on a case-by-case basis the best approach to the program. This is an ongoing effort to determine an effective solution to benefit all parties involved.

STREAMLINING CERTAIN DUPLICATIVE OIL & GAS RESPONSIBILITIES

Private industry has long maintained that there are obvious problems when oil and gas operators attempt to comply with differing orders from different jurisdictions which cover the same issue or problem. Of special concern to industry, is "downhole" approvals, that is, approvals concerning operations that are performed at or close to the bottom of the well or adjacent to the production zones. To address this issue, the Interstate Oil and Gas Compact Commission (IOGCC) established the Public Lands Project to identify opportunities that would promote regulatory efficiencies between the States and the Federal government. The Public Lands Project recommended that certain "downhole" responsibilities be regulated by the respective State oil and gas commissions without duplication of these responsibilities by the BLM. These responsibilities include: pooling rules, including spacing and drainage considerations,

flare/no flare rules, commingling orders, groundwater protection, multiple zone completions, directional drilling and enhanced oil recovery determinations.

Bob Armstrong, Assistant Secretary for Lands and Minerals Management, has concurred in principle with the recommendations of the IOGCC's Public Lands Project and has determined that their recommendations are consistent with the Administration's initiatives to reduce regulatory burdens and streamline government. He has directed the BLM to review Departmental regulations and procedures and existing agreements with State oil and gas regulatory commissions, and to amend or create new agreements to ensure all orders and decisions involving those areas listed in the recommendations are addressed. We anticipate this effort will result in improved efficiency of the regulatory process for oil and gas development on public lands.

These examples demonstrate the Bureau of Land Management's commitment to responding to its customers' needs and also provides an example of how this Administration has worked with industry and others through the Performance Review to identify problems and reach collaborative solutions. Our efforts illustrate the ability of Federal agencies to cooperate effectively, share resources and produce results that help secure the future of our domestic oil and gas industry. We have moved full speed ahead towards shared responsibility and enhanced technology.

GREEN RIVER BASIN ADVISORY COMMITTEE

Natural gas is the cornerstone of the Clinton Administration's domestic energy policy. The Department of the Interior believes that the natural gas resources within the Greater Green River Basin probably represent the most significant onshore natural gas resource underlying primarily Federal lands in the lower 48 states.

On February 7, 1996, the Secretary of the Interior established the Green River Basin Advisory Committee (GRBAC) to advise him on all aspects of the BLM's activities that affect or are influenced by our natural gas and oil program in the Greater Green River Basin. The Greater Green River Basin is an area of intense oil and gas development, and the GRBAC will provide a means for addressing concerns of both industry and the environmental community while facilitating environmentally responsible development of oil and gas resources in the Greater Green River Basin of Wyoming and Colorado. The Committee will provide a regionally focused forum to address and make recommendations to resolve controversial issues related to the recovery of natural gas and oil without sacrificing environmental values.

Governor Jim Geringer has added his voice in support of this committee by saying, "I support the balance and diversity of the parties involved. If we are to build a consensus for what is best in Wyoming and the entire Green River Basin, we have to hear from everyone. I am satisfied that we now have a well balanced coalition."

To ensure a balance of views from the interested public, 17 voting members have been appointed by Secretary Babbitt. They include representatives of the oil and gas industry, environmental organizations, resource conservation groups, and State and local officials. The Committee also includes a private landowner. These individuals will work cooperatively on recommendations to the Secretary to address how to ensure that mineral development takes place in a manner that reflects our nation's long-term interest in resource conservation.

The Committee is NOT a decisionmaking body or another "layer of bureaucracy" to impede the BLM's decisionmaking process. The Committee has no authority to impose new regulations or restrictions. Its function is strictly to advise the DOI and BLM on how best to

manage two **World-Class** resources---natural gas and oil and unparalleled wildlife resources.

The Committee's work is scheduled to be completed by March 1997 and will culminate in a report of consensus-based recommendations that will ensure continued development of the tremendous natural gas and oil resource potential, while also ensuring equal consideration and protection of the wildlife resources within the Greater Green River Basin.

The Committee has already held its first meeting (3-7/8-96) in Rock Springs, Wyoming. The Committee has also identified dates for their next three meetings to be held in Rock Springs & Craig, Colorado in the months of April, May and June of this year.

CONFLICT RESOLUTION AND TECHNOLOGICAL ADVANCES

Not only have we made strides in the area of collaborative effort and cooperative agreements but we also have seen improvements in areas of conflict resolution and use of automation.

For example, in the Delaware Basin of New Mexico, there is concern about production from Federal oil and gas leases in areas containing potash deposits. The concern centers around possible contamination of potash deposits due to oil and gas drilling operations. The BLM has brought interested parties together, including members of the potash and oil and gas industries, State and local governments, and the conservation community, to seek consensus on an acceptable solution.

We are also pursuing methods of improving the way we serve our customers by allowing for increased flexibility in the application of our Resource Management Plans (RMP). More

flexible RMPs will allow for more diverse avenues in accomplishing the rights of the lessor under authorization for issuance of leases and the approval of permits or applications. The BLM is conducting a pilot study in the White River Resource Area of Colorado to see where we can use natural resource based tradeoffs along with performance based stipulations to achieve this goal, rather than the current RMPs with specific/standard stipulations.

The BLM is also advancing in the areas of technology and automation. The Automated Fluid Minerals Support System (AFMSS) is designed to automate processes associated with oil and gas leasing activities. This includes lease operations, inspection and enforcement (I & E), and reservoir management and focuses on capturing basic information and tracking the processing of applications, reports, approvals, and permits as well as I & E activities. Enhancements, including electronic commerce, which provides for the electronic exchange of data, and integration with Geographic Information System (GIS) and Automated Lands and Minerals Recordation System (ALMRS) will be implemented by FY 1997. We are currently operating pilot stations in Farmington, New Mexico and Bakersfield, California.

We are also working with the oil and gas and computer industries to develop database, and data exchange standards covering almost all aspects of the exploration and production phases of the oil and gas industry. The goal is for industry and government to adopt these standards so we can all take a giant step towards paperless transactions.

Mr. Chairman, I welcome the committee's continued interest in the BLM's programs and budget, and I appreciate this opportunity to provide our overview of the direction we are taking in oil and gas programs. I look forward to responding to any questions you or other members of the

Committee might have.

Attached is additional information regarding these programs.

FY 1995 – Applications For Permit To Drill, Federal Leases

BLM State Office	Received	Approved	Rejected/Withdrawn	Pending approval
Alaska	5	3	2	1
Arizona	1	0	0	1
California	132	138	5	6
Colorado	102	100	21	23
Eastern States	61	66	1	17
Montana	93	88	4	21
Nevada	28	29	6	13
New Mexico	935	860	111	186
Utah	239	220	14	64
Wyoming	613	488	80	263
Total	2,209	1,992	244	595

****These #'s Reflect Carryovers From Previous Fiscal Years

BLM ONSHORE OIL AND GAS LEASING ACTIVITIES UNDER THE REFORM ACT

Acreage Offered/Sold By Competitive Sale and Acreage Issued Noncompetitive

Fiscal Year	Acreage Offered Competitively	Total Bonus Bid Monies	Acreage Sold Competitively	Noncompetitive Acreage Issued	Total Acreage Issued
1988*	9,597,224	44,381,422	2,217,189	2,333,802	4,550,991
1989	14,964,030	62,847,020	2,832,413	3,818,604	6,651,017
1990	9,026,951	49,204,788	1,935,164	3,937,715	5,872,879
1991	7,849,609	41,493,132	1,845,525	2,454,637	4,300,162
1992	7,897,723	18,595,550	1,108,248	1,947,582	3,055,830
1993	7,543,664	22,747,870	1,744,697	1,403,482	3,148,179
1994	5,794,881	41,430,784	2,147,415	1,644,758	3,792,173
1995	6,105,837	47,313,046	2,394,852	1,453,104	3,847,956

* Partial FY-88 (Federal Onshore Oil and Gas Reform Act enacted 12/22/87)

Sources: BLM, Public Land Statistics
OGSTATS.DBF (BLM dBase IV File)

Testimony
of
David W. Houseknecht
U. S. Geological Survey
to
Committee on Resources
Subcommittee on Energy and Mineral Resources
U.S. House of Representatives
March 21, 1996

Mr. Chairman and Members:

I am David W. Houseknecht, Program Coordinator for the Energy Resource Surveys Program at the U.S. Geological Survey (USGS). I have been asked to provide testimony on USGS estimates of the onshore oil and gas resource base of the United States. My comments will include a description of the methodology used to make these estimates and certain conclusions that can be drawn from the results.

I. Summary

As part of its mission to evaluate the energy and mineral resources of the Nation, the USGS periodically conducts an assessment of the oil and natural gas resources of the onshore and state water areas of the United States. In February 1995, the USGS released the results of the most recent oil and gas assessment, an intensive four-year study. The Minerals Management Service (MMS) is conducting a parallel study of the oil and gas resources of the Federal offshore areas.

The USGS study indicates that the domestic resource base of technically recoverable hydrocarbons in onshore and State water areas includes at a mean estimate approximately 142 billion barrels of crude oil (including natural gas liquids) and 1,074 trillion cubic feet of natural gas. These estimates will be placed into a context of geographic distribution in the remainder of this testimony.

II. Commodities Assessed and Assessment Categories

Three commodities were considered in the USGS national assessment: crude oil, natural gas, and natural gas liquids. Natural gas liquids are typically gaseous hydrocarbons in the subsurface, and are liquified at the surface in various field facilities and in gas-processing plants. Although reported separately in the USGS national assessment, crude oil and natural gas liquids are considered collectively in this testimony.

The USGS study assessed three categories of resources: (1) undiscovered conventional accumulations of oil and gas, (2) oil and gas in continuous-type accumulations (so-called "unconventional" resources), and (3) inferred reserves, or future growth of reserves in existing fields. In addition, a fourth category of oil and gas resources, (4) measured (proved) reserves, was reported for the sake of completeness. This fourth category represents information that is collected and reported by the Energy Information Administration.

(1) Undiscovered conventional accumulations of oil and gas, the traditional fare of the petroleum industry, generally occur as discrete accumulations whose distribution is usually controlled by hydrocarbon-water contacts. These resources are postulated to exist outside existing fields.

(2) Continuous-type accumulations include those oil and gas resources that occur as geographically extensive accumulations that generally lack well-defined hydrocarbon-water contacts. Included in this category of resources are coal-bed gas, gas in "tight sandstone" reservoirs, and oil and gas in fractured shale formations.

(3) Inferred reserves (reserve growth) include those resources expected to be added to reserves as a consequence of extension of known fields, through revisions of reserve estimates, by additions of new pools in existing fields, and through application of improved recovery techniques.

III. Assessment Methods

A detailed description of the methods used in the USGS national oil and gas assessment is included in USGS Digital Data Series 30, an interactive CD-ROM that contains a comprehensive summary of the USGS 1995 national assessment. All the methods used in conducting the USGS national assessment were reviewed by assessment experts from other Federal agencies, State agencies, universities, and the petroleum industry.

The assessment of undiscovered conventional and continuous-type resources was based on analysis of hydrocarbon plays. A play is a set of confirmed or hypothetical hydrocarbon accumulations that share common attributes such as source rock, reservoir rock, and trap. Plays were delineated based on the study of the geology of every geologic province of the Nation. Once delineated and described, every play was reviewed by State geological surveys within the appropriate region. In addition, most plays were reviewed by geologists from other Federal agencies and the petroleum industry at regional workshops, many of which were organized by the Resource Evaluation Committee of the American Association of Petroleum Geologists (AAPG).

A variety of specific methods were used to assess oil and gas resources at the play level depending on the resource category, the availability of exploration and production data, and whether or not the play had been confirmed by the discovery of at least one oil or gas field. Geologic risk was incorporated into the analysis using the geologic factors that control the occurrence of oil and natural gas. Once estimates of undiscovered resources were completed for each play, results were progressively aggregated to the province, region, and national levels with geological dependency incorporated at each level.

Estimates of recoverable oil and gas in fields smaller than 1 million barrels of oil or 6 billion cubic feet of gas were made separately. These estimates were based on the abundance of existing and postulated fields of larger size and extrapolations of those data to fields of smaller size.

Estimates of reserve growth are based on USGS analysis of data in the Oil and Gas Integrated Field File (OGIFF), which is a proprietary data base compiled and archived by the Energy Information Administration. Growth functions were calculated for the historical data, and those functions were applied to future growth of existing fields to estimate the volume of oil and gas that may be added to reserves in the future.

Finally, it is important to note that USGS estimates of undiscovered conventional and continuous-type accumulations normally are reported as a range of values to express the uncertainty involved in assessing these types of resources. Values reported in this testimony, however, are limited to the mean values for convenience.

IV. Results - Crude Oil

The estimated total oil resource base for the onshore and State water areas of the United States is 142 billion barrels. Of that total, measured (proved) reserves account for 27 billion barrels (19 percent), future growth of reserves in existing fields accounts for 73 billion barrels (51 percent), undiscovered conventional accumulations account for 38 billion barrels (27 percent), and continuous-type resources account for 4 billion barrels (3 percent).

Seventy percent of the estimated oil resource base is represented by reserves in existing fields plus anticipated growth in those reserves. This conclusion mirrors the fact that during the past decade, reserve growth has accounted for more than 90 percent of total additions to domestic reserves, and suggests that much of the future oil production in the United States will continue to be focused in the same areas as in the recent past. These observations also suggest that advanced production technologies, such as horizontal drilling and 3-D seismic, have contributed substantially to slowing the decline in domestic oil production. In addition, the importance of reserve growth underscores the need for the Nation to maintain a viable domestic oil production capability.

Undiscovered conventional accumulations represent a significant part (27 percent) of the estimated oil resource base, and these resources are thought to be concentrated in a few regions of the United States. Alaska and the Gulf Coast regions hold the greatest potential, each with approximately 10 billion barrels, and the Rocky Mountains - Northern Great Plains region has significant potential of about 8 billion barrels. Among these three regions, the lands in Alaska and in the Rocky Mountains - Northern Great Plains region are predominantly or in substantial part owned or managed by the Federal Government, and large parts of the Gulf Coast are environmentally sensitive areas (e.g., coastal wetlands).

V. Results - Natural Gas

The estimated total natural gas resource base for the onshore and State water areas of the United States is 1,074 trillion cubic feet. Of that total, measured reserves account for 135 trillion cubic feet (13 percent), future growth of reserves in existing fields accounts for 322 trillion cubic feet (30 percent), undiscovered conventional accumulations account for 259 trillion cubic feet (24 percent), and continuous-type resources account for 358 trillion cubic feet (33 percent).

In contrast to oil resources, just 43 percent of the estimated natural gas resource base is represented by measured reserves in existing fields plus anticipated growth in those reserves. Nevertheless, the size of this number emphasizes the importance to domestic natural gas production of the continued development and application of advanced production technologies, as well as a healthy domestic production capability.

Well over half of the estimated natural gas resource base is thought to occur in undeveloped areas outside existing fields. Undiscovered conventional accumulations represent a significant proportion (24 percent) of this resource. The Gulf Coast and Alaska regions hold the greatest promise for large volumes of gas in conventional accumulations, with approximately 98 and 68 trillion cubic feet, respectively.

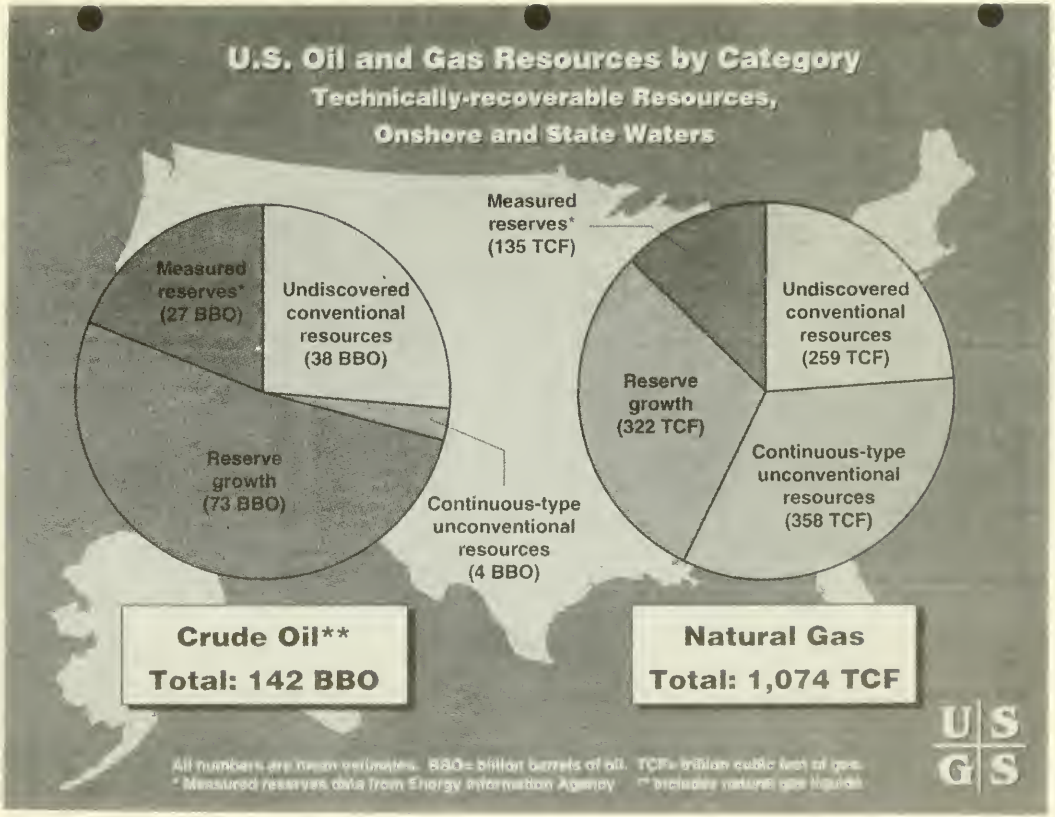
Natural gas in continuous-type (unconventional) accumulations represents an even larger potential resource, at 33 percent of the total gas resource base. These resources are thought to be concentrated primarily in two regions. The Rocky Mountain - Northern Great Plains region holds a potential of approximately 166 trillion cubic feet, mainly in low permeability sandstone formations ("tight gas sands"). The Eastern region also has very large potential for gas in continuous-type accumulations, with an estimated 83 trillion cubic feet in fractured shale formations, mostly in the Appalachian and Michigan Basins, plus an estimated 19 trillion cubic feet of coal-bed gas in the Appalachian Basin.

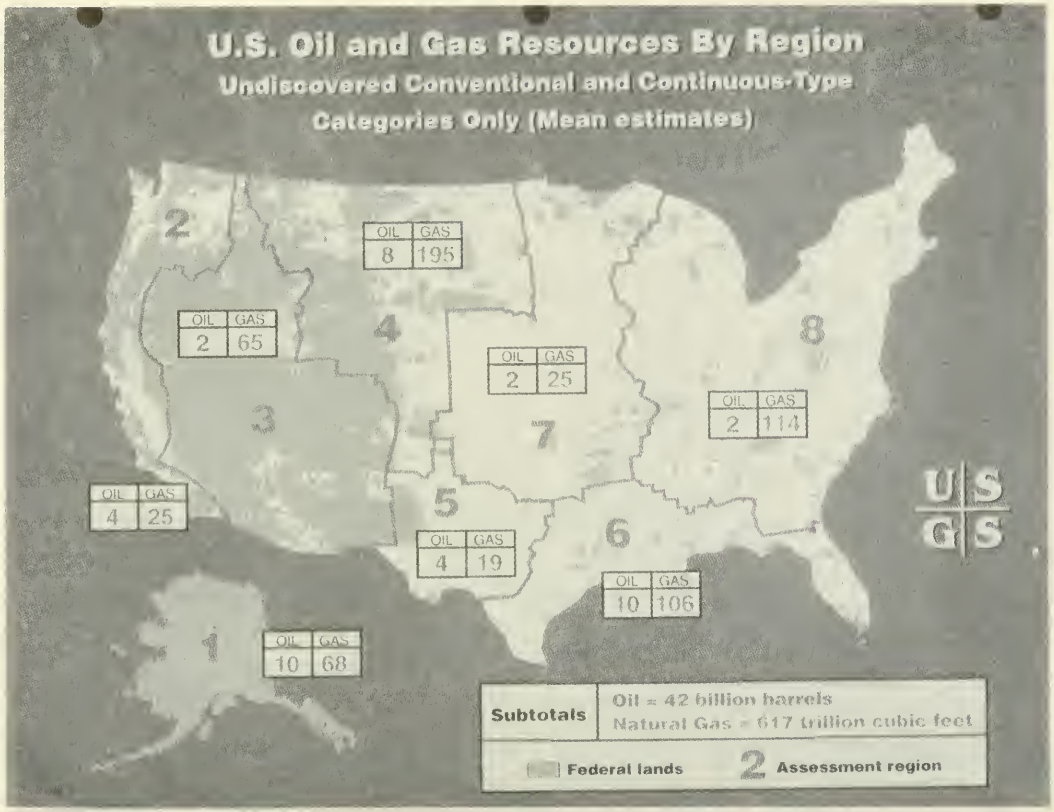
The Colorado Plateau - Basin and Range region also is worthy of mention, not only because it has significant gas potential, but because a large proportion of the land within the region is under Federal stewardship. The region is estimated to contain approximately 9 trillion cubic feet of gas in undiscovered conventional accumulations and 56 trillion cubic feet of gas in continuous-type accumulations (both low-permeability sandstone formations and coal-bed gas).

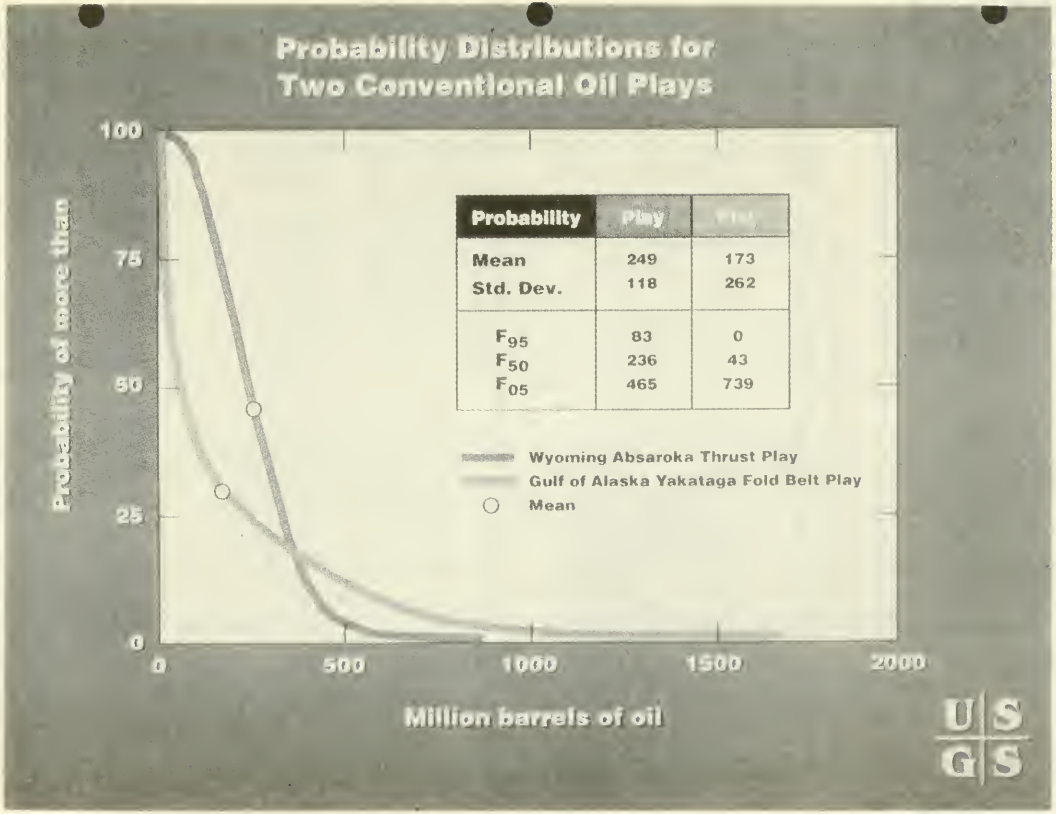
Among the regions with the greatest potential for natural gas resources, Alaska, the Rocky Mountains - Northern Great Plains, and the Colorado Plateau - Basin and Range regions are predominantly owned or managed by the Federal Government, and large parts of the Gulf Coast are environmentally sensitive areas.

VI. Conclusions

In summary, the USGS estimates that the United States has significant oil and natural gas potential in onshore and State water areas. Regions of the United States that have the greatest potential for oil and natural gas are also regions where either much of the land is under Federal stewardship or is considered environmentally sensitive. We hope the results of the USGS national oil and gas assessment will be useful in making land management and regulatory decisions.


U.S. Oil and Gas Resources by Category
Technically-recoverable Resources,
Onshore and State Waters
Measured reserves* (27 BBO)
Undiscovered conventional resources (38 BBO)
Reserve growth (73 BBO)
Continuous-type unconventional resources (4 BBO)
Crude Oil**
Total: 142 BBO
Measured reserves* (135 TCF)
Undiscovered conventional resources (259 TCF)
Reserve growth (322 TCF)
Continuous-type unconventional resources (358 TCF)
Natural Gas
Total: 1,074 TCF
All numbers are mean estimates. BBO= billion barrels of oil. TCF= trillion cubic feet of gas.
* Measured reserves data from Energy Information Agency ** Includes natural gas liquids
U S
G S


U.S. Oil and Gas Resources By Region
Undiscovered Conventional and Continuous-Type
Categories Only (Mean estimates)
2
OIL 8 GAS 195
OIL 2 GAS 65
4
OIL 2 GAS 25
8
OIL 2 GAS 114
3
7
OIL 4 GAS 25
5
OIL 4 GAS 19
6
OIL 10 GAS 106
1
OIL 10 GAS 68
USGS
Subtotals
Oil = 42 billion barrels
Natural Gas = 617 trillion cubic feet
Federal lands
2 Assessment region


Probability Distributions for
Two Conventional Oil Plays
Probability of more than
100
75
50
25
0
0
500
1000
1500
2000
Million barrels of oil
Probability
Play
Play
Mean
Std. Dev.
249
118
173
262
F_{95}
F_{50}
F_{05}
83
236
465
0
43
739
Wyoming Absaroka Thrust Play
Gulf of Alaska Yakataga Fold Belt Play
Mean
U S
G S

Selected Issues in
THE USGS ENERGY RESOURCE SURVEYS PROGRAM

U.S. DEPARTMENT OF THE INTERIOR U.S. GEOLOGICAL SURVEY

A Summary of the U.S. Geological Survey 1995 National Assessment of Oil and Gas Resources

"Assuming existing technology, there are approximately 110 billion barrels of technically recoverable oil onshore and beneath State waters; additional resources occur beneath Federal offshore areas. This includes measured (proved) reserves, future additions to reserves in existing fields, and undiscovered resources. The technically recoverable conventional resources of natural gas in measured reserves, future additions to reserves in existing fields, and undiscovered accumulations equal about 715 trillion cubic feet."

—Dr. Dan Gautier
U.S. Geological Survey

The U.S. Geological Survey (USGS) has completed its portion of the 1995 National Assessment of Oil and Gas Resources.

The purpose of this assessment is to scientifically estimate the amount of oil and gas that could be added to the proved reserves of the United States. The word assessment sometimes connotes an inventory; however, that is not the case in this study. The quantities evaluated here are largely unknown. This assessment attempts to bound the uncertainties concerning potential additions to oil and gas reserves in the onshore areas and beneath State waters. As such, this assessment consists of a set of conclusions based on the best information and theory available to the USGS for those regions. Additional resources reside beneath offshore Federal waters and are being assessed by the Minerals Management Service. The geological assessment of technically recoverable resources makes no attempt to predict at what time or what part of potential additions will be added to reserves. For this National Assessment, resources and potential reserve additions are evaluated regardless of political or economic considerations.

Oil and gas assessment categories for the 1995 assessment are broader in scope than for previous national assessments.

The 1995 assessment considers three categories of resources: undiscovered conventional accumulations of oil and gas; future additions to reserves of known fields (reserve growth or field growth); and, oil and gas in continuous-type accumulations (largely equivalent to "unconventional" categories of other analysts). Each of these three broad categories of resources requires different techniques for evaluation.

Undiscovered conventional accumulations of oil and gas include those postulated to exist outside known fields or accumulations and that, if found, could be recovered using traditional development practices. They exist as discrete accumulations which usually, but not invariably, are defined, controlled, or limited by hydrocarbon/water contacts.

Category	Crude oil (billion barrels)			Gas (trillion cubic feet)			NGL (billion barrels)		
	F_{95}	F_5	Mean	F_{95}	F_5	Mean	F_{95}	F_5	Mean
Undiscovered conventional resources	23 5	39 6	30 3	207 1	329 1	258 7	5 8	8 9	7 2
Reserve growth in conventional fields	NA	NA	60 0	NA	NA	322 0	NA	NA	13.4
Continuous-type accumulations in sandstones, shales, and chalks	1 5	2 7	2.1	219 4	416 6	308.1	1 1	3 5	2 1
Continuous-type accumulations in coal beds	NA	NA	NA	42 9	57 6	49 9	NA	NA	NA
Measured (proved) reserves	NA	NA	20 2	NA	NA	135 1	NA	NA	6 6
TOTAL, onshore areas and State waters of the United States			**112 6**			**1,073 8**			**29 3**

Estimates of national totals for undiscovered technically recoverable conventional oil, gas, and natural gas liquids (NGL) resources, growth of reserves in known fields, technically recoverable resources in continuous-type (unconventional) accumulations, and measured reserves. Gas includes both non-associated and associated-dissolved gas. Fractile values (F_{95}, F_5) are not additive. F_{95} represents a 19 in 20 chance and F_5 represents a 1 in 20 chance of the occurrence of at least the amount tabulated. NA, not applicable.

Inferred reserves include resources expected to be added to reserves as a consequence of extensions to known fields, through revisions of reserve estimates, and by additions of new pools in discovered fields. Also included in this category are resources expected to be added to reserves through application of improved recovery techniques. Predictions of reserve growth refer to fields found before 1992, the date of most reserve data used for this National Assessment.

For purposes of this assessment, continuous-type accumulations are defined to include those oil and gas resources that exist as geographically extensive accumulations and that generally lack well-defined oil/water or gas/water contacts. This geologically-grounded definition provides a set of consistent criteria to be applied in the determination of whether a specific accumulation is conventional. Such a geological definition intentionally avoids regulatory criteria and does not rely on specific permeability as a defining criterion. Included in this category are coalbed gas, gas in many of the so-called "tight sandstone" reservoirs, and auto-sourced oil- and gas-shale reservoirs. Because of the immense quantities of oil and gas that can be included in this category, only those resources judged to be technically recoverable and that could be added to U.S. oil and gas reserves are reported.

Aggregation of oil and gas resource estimates include geological dependencies between assessment units.

To arrive at the estimated quantity of undiscovered resources for large areas, such as provinces, regions, or the Nation as a whole, distributions estimated for basic assessment units were progressively aggregated with geological dependency incorporated at each level. In order to aggregate plays within provinces, geological dependencies between plays were established for the three basic attributes of charge, reservoir, and trap. Province geologists determined for each pair of plays in their province whether the geological dependence was high, moderate, or low. For aggregation of province-level estimates, the provinces within each region were assigned a moderate dependency. In aggregation of regions for a national total, regions were considered to be geologically independent.

Oil and gas resource estimates are based on a thorough geological and statistical analysis of available data and information.

Within the areas of the USGS assessment, 560 plays were identified, of which about 100 were ***continuous***-type plays and the remaining were ***conventional*** plays. Of the 460 ***conventional*** plays defined for the 1995 National Assessment, 373 conventional plays were assessed. Of these assessed plays, 290 are confirmed plays and 83 are hypothetical plays. The mean estimate of undiscovered technically recoverable conventional oil resources is slightly more than 30 billion barrels of oil. Of this amount, more than 6 BBO exist in accumulations smaller than 1 million barrels of oil. The mean estimate of undiscovered technically recoverable conventional natural gas is nearly 259 trillion cubic feet. Of this amount, about 45 TCF exist in accumulations smaller than 6 billion cubic feet of gas. The mean estimate of undiscovered natural gas liquids (NGL) is about 7 billion barrels of NGL. It is calculated that reserve growth will add 60 BBO to oil reserves in known fields and 322 TCF will be added to natural gas reserves in known fields during the 80 years following 1991. Technically recoverable hydrocarbon resources from continuous-type accumulations are substantial. The mean estimate for natural gas resources exceeds 300 TCF; the mean estimate for crude oil is about 2 BBO; the mean estimate for natural gas liquids is about 2 BBNGL. For this assessment, the mean estimate of technically recoverable resources of coalbed gas for the lower 48 States is nearly 50 TCF

A—Technically recoverable oil resources of the United States, exclusive of Federal offshore. BBO, billion barrels of oil, MMBO, million barrels of oil. B—Technically recoverable gas resources of the United States, exclusive of Federal offshore. TCFG, trillion cubic feet of gas, BCFG, billion cubic feet of gas

The USGS 1995 National Assessment is the most thorough, well-documented, user-friendly assessment of oil and gas resources ever assembled.

The results of the assessment are available on a USGS CD-ROM which is a companion to an executive summary in a USGS Circular. Both products are available through U.S. Geological Survey, Information Services, Box 25286, Federal Center, Denver, CO 80225. Though this National Assessment generated very large amounts of data and information, the message is clear. The National Assessment confirms observations that oil production in the United States is in decline as it has been since 1971. But, the future is uncertain. The decline will be less pronounced if, for example, oil prices move higher because this may encourage domestic petroleum exploration. The natural gas situation is different. Production has not yet peaked and the resource is more plentiful. But, this assessment shows that, even to maintain delivery at present levels, industry will need to increase drilling and the Nation will have to address a variety of technological and land-use considerations. As the United States approaches the 21st century, more and more energy is consumed, much of it from fossil fuels. In the United States, a variety of energy sources contributes to meeting needs. Sometimes they compete vigorously. Over the past two decades, citizens have become increasingly aware that use of each source of energy carries with it indirect costs, such as atmospheric change, health risks, damage to land, and vulnerability of supply. Finding solutions to these problems will be a difficult task that requires information that is scientifically-based and non-advocacy in nature. The National Assessment provides just such a view of the oil and gas resources of the United States.

For more information please contact: Dr. Don Gautier, USGS, MS 960, Denver Federal Center, Denver, CO 80225 (303) 236-5740

TESTIMONY OF

Thomas A. Readinger

Deputy Associate Director for Resources and Environmental Management
Minerals Management Service
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Before the

Energy and Mineral Resources Subcommittee
Resources Committee
House of Representatives

March 21, 1996

Mr. Chairman and Members of the Subcommittee, I appreciate the opportunity to appear today to present testimony on the Minerals Management Service (MMS) estimates for the United States Outer Continental Shelf (OCS) crude oil and natural gas resource base and the underlying methodology used by the Minerals Management Service (MMS) in creating these estimates.

Background

As you are aware, the MMS consists of two major programs: the Royalty Management Program and the Offshore Minerals Management Program. As such, all mineral revenue management functions for Federal (onshore and offshore) and Indian lands are centralized within MMS. Further, the leasing and oversight of mineral operations on the OCS is also centralized within the bureau. Together, these programs contribute significantly to the Nation's economic well-being and its energy security. For example, approximately $4 billion in mineral revenues are collected and distributed on an annual basis from Federal and Indian lands, and OCS natural gas and oil production account for roughly 24 and 15 percent, respectively, of our Nation's domestic energy production.

In its role as manager of the Nation's OCS energy and non-energy mineral resources, the bureau's long-term strategy is to assess those resources; determine, in consultation with affected parties, if they can be developed in an environmentally sound manner; and, if leased, to regulate activities to ensure safety and environmental protection. This long-term strategy affects the way MMS manages OCS resources and the way MMS faces the challenge of maintaining a "balance" between providing energy and protecting the Nation's unique and sensitive environments and other natural resources.

An integral element in this long-term strategy is the ability to determine the most promising areas

of the OCS for the occurrence of natural gas and crude oil accumulations and to quantify the amounts of natural gas and crude oil that may exist in these areas. However, since much of the OCS has not been thoroughly explored, we must deal with the uncertainty that these resources may or may not exist in these most promising areas. We must also develop indicators of the economic viability of these resources under a variety of economic and price scenarios and costs associated with exploration, development, and production activities for the specific areas where the resources may occur. Within MMS, these functions are performed through the Resource Evaluation (RE) Program component of the Offshore Minerals Management Program.

MMS Resource Evaluation Program

The RE Program is focused upon the acquisition and analysis of geologic, geophysical, petroleum engineering, and economic data and information related to the minerals potential (predominately natural gas and crude oil) of OCS lands. The primary source of this data and information is the oil and natural gas industry which conducts exploration, development, and production activities on OCS lands. MMS acquires this data under terms of lease agreements or permits. Hence, the data and information is considered "proprietary" by MMS and generally not available for public release.

RE Program functions encompass all cycles of OCS program activities and provide technical data and information supporting a wide array of program and regulatory decisions affecting Offshore Minerals Management-- including OCS leasing decisions, bid adequacy determinations, environmental analyses, royalty-relief considerations and a myriad of related issues and decisions that must incorporate specific knowledge about the amounts of natural gas and crude oil resources and reserves.

In performing these functions, MMS personnel must constantly update the information databases to reflect new data produced by current drilling and seismic activities performed by industry as well as update production data from known fields as natural gas and crude oil are produced from OCS fields. There are several "by-products" that result from our ongoing geologic, economic, and engineering analyses. For example, MMS publishes annual reports that update the estimates of proved reserves for Gulf of Mexico and Pacific OCS fields. Additionally, MMS submits biennial reports to Congress in accordance with the provisions of the section 606(c), (d), and (e) of the OCS Lands Act, as amended (P.L. 99-367, section 2(c)). These reports provide updated estimates of the undiscovered natural gas and oil resources that may exist on OCS lands as well as updated reserves estimates.

OCS Resource Assessments

As background to discussing any resource estimates of natural gas and crude oil accumulations on the OCS, it is important to understand the differences between the terms "undiscovered resources" and "known reserves."

"Undiscovered resources" are quantities of natural gas and crude oil that geologic data and information suggest may exist in areas outside of known oil and natural gas fields. However, verification of the existence of natural gas and/or crude oil can only be determined from exploratory drilling activities and verification of the ultimate number and sizes of fields is only truly known after an area has been thoroughly explored, developed, and all discoveries produced-- a timeframe generally covering decades.

"Known reserves" are those natural gas and crude oil deposits that have been discovered and determined to be economically viable to develop and produce. Estimates of known reserves are reported in two categories by MMS: "Proved" reserves are those accumulations that have existing production and transportation facilities or regulatory commitments for installation of such facilities. "Unproved" reserves are those accumulations that have been discovered, but lack sufficient geologic and economic studies by MMS and OCS lessees to determine whether such discoveries can be commercially developed.

Finally, MMS resource estimates address conventionally recoverable natural gas and crude oil quantities--that is, estimates do not include deposits of "heavy oil,"oil shales, gas hydrates, coalbed methane, or similar continuous-type hydrocarbon deposits.

OCS Reserve Estimates

As of January 1, 1995, MMS estimates of "proved" reserves for the Gulf of Mexico region are 2.5 billion barrels of oil (Bbbl) and 29.3 trillion cubic feet (TCF) of natural gas. "Proved" reserves for the Pacific region are estimated at 0.7 Bbbl of oil and 1.6 TCF of natural gas. Additionally, MMS estimates of "unproved" reserves for the Gulf of Mexico region are 0.9 Bbbl of oil and 4.7 TCF of natural gas and 0.6 Bbbl of oil and 0.8 TCF of natural gas for the Pacific region.

Previous OCS Resource Assessments

Since its creation in 1982, MMS has completed two systematic assessments of Federal OCS undiscovered oil and natural gas resources. The results of the first resource assessment and the methodologies used to develop these estimates were published in a 1985 MMS report entitled *Estimates of Undiscovered, Economically Recoverable Oil and Natural Gas Resources for the the Outer Continental Shelf as of July 1984*. Following release of the 1985 MMS report, MMS agreed to join the U.S. Geological Survey (USGS) in conducting a joint, concurrent resource assessment of the United States (both onshore and offshore) in order to provide the Department of the Interior, Congress, and other public and private organizations with estimates reflecting consistent timeframes. The results of this "National Assessment" were published in 1989 in a joint MMS/USGS publication entitled *Estimates of Undiscovered, Conventional Oil and Gas Resources in the United States - A Part of the Nation's Endowment.* Subsequently, MMS reported a more detailed set of results from this joint assessment in 1990 in an MMS report

entitled *Estimates of Undiscovered Oil and Gas Resources for the Outer Continental Shelf as of January 1987*.

Following the first MMS assessment, a National Academy of Sciences (NAS) panel reviewed MMS resource assessment and resource estimation methodologies and recommended certain changes for future assessments. Similarly, a NAS panel also reviewed MMS procedures employed in its second resource assessment and additional recommendations were published.

In view of the importance of such estimates to outside private and public interest groups, additional reviews of the MMS (and USGS) methodologies and reporting procedures were conducted by the Association of American State Geologists (AASG), the Energy Information Administration (EIA, U.S. Department of Energy), and the American Petroleum Institute (API). The AASG and EIA reviews resulted in published reports with technical recommendations for enhancing the methodologies employed by both MMS and USGS, while the API review resulted in private recommendations to the Department.

In preparation for conducting its third systematic OCS resource assessment, MMS not only took into account the technical recommendations of NAS and others but also looked internally at other ways to improve on its past efforts. Because the results of the resource assessment would be used by different customers, each with different information needs and levels of technical sophistication, the bureau devoted considerable time and attention to improving on the way the estimates are made and how they are reported. Customers (user groups) surveyed include:

- MMS/DOI decisionmakers;
- Federal and State Agencies and Congress;
- Oil/Gas and related industries;
- Geologic and scientific communities and academia; and
- the general public.

Current OCS Resource Assessment

Armed with the technical recommendations and the realistic conclusion that the needs of our customers (including ourselves) could be better met, MMS embarked on an effort in 1991 to revise our resource estimation and reporting procedures. Our specific goals were to establish a method for estimation that: (1) maintained the strong points of earlier methodologies; (2) utilized the extensive amount of proprietary geological and geophysical data within MMS databases to the fullest extent; and (3) provided MMS geologists flexibility to use their judgment to capture a broad range of possible geologic interpretations to address specific areas. In

addition, we wanted to:

- Produce functional/understandable results;
- Reflect the high quality science inherent in the MMS activities addressing resource assessment and estimation;
- Ensure that estimates reflect geologic potential (known and unknown) as well as reflect risks and uncertainties;
- Separate determinations of economic viability from the process of estimating geologic potential; and
- Report estimates and related information to a broader audience.

The Petroleum Exploration and Resource Evaluation System (PETRIMES), a probabilistic play analysis model which is currently used by the Geological Survey of Canada, was chosen as the basic platform for the present assessment of geologic resources. Most of the resource assessment models currently in use, by either industry or other government agencies, provide estimated resources in aggregated numbers representing total resources as a distribution. However, PETRIMES can also provide an estimate of the number and size of oil and natural gas pools that remain to be discovered. That information is very useful for planning and decisionmaking processes related to exploration and development of OCS resources. One drawback to PETRIMES, however, is that it was designed to assess a single commodity play, such as an oil play or a gas play. In reality, OCS plays are (in most cases) mixed plays containing both oil and gas pools. In order to utilize PETRIMES for the assessment of OCS resources, MMS implemented a number of changes to the original PETRIMES program. The most important change made to the program was to provide the ability to separate estimation of both liquid (condensates and oil) and gas (associated gas and nonassociated gas) phases required for an accurate economic evaluation of the OCS. The modified version of PETRIMES is called the Geologic Resource Assessment Program (GRASP).

The Probabilistic Resource Estimation Offshore (PRESTO) model, developed by MMS and used in its 1987 assessment, was modified to accept the assessed output of GRASP at the pool level to determine the economically recoverable resources at the geologic basin level and higher. Unlike the 1987 resource assessment, where economic resources were estimated for only two sets of distinct oil and gas prices inflated over time, the present assessment depicts the uncertainty of assessed results by providing a continuous series of resource values over a range of prices (price supply curves) for each geologic basin, province, and area.

In addition to adopting revised geologic modelling approaches and computer models in its current resource assessment, the MMS also opened up the process of developing estimates for the OCS by holding public workshops for industry, academia, and other interested parties to

discuss MMS geologic interpretations and assumptions to be used in the estimation process. We also retained the services of two outside experts in the petroleum assessment community, both of which served on NAS panels reviewing previous MMS assessments, to provide technical advice to MMS scientists.

Finally, we are planning to publish the results of our third OCS resource assessment in a format that will allow for more openness in OCS resource management decisions--reporting maps of the most promising plays, estimates of the number and sizes of accumulations that may exist within these areas, price-supply curves for examining the impacts of uncertain future oil and natural gas prices on the economic viability of the resources, and a substantial amount of supporting assumptions and underlying geologic information.

Status of Current MMS Resource Assessment

MMS's third systematic OCS resource assessment is currently underway and is expected to be completed later in 1996. The overall assessment will contain both a "geologic assessment" section and an "economic viability" section. In view of the extensive amount of data and information we envision making available when our resource assessment is completed, MMS plans to issue an "Executive Summary" of its OCS resource estimates as well as provide technical, in-depth results through three regional reports (Gulf of Mexico/Atlantic Region, Pacific Region, and Alaska Region). Further, regional offices may release interim reports that provide more detailed information than that published in the "Executive Summary" prior to release of the regional reports.

Since we are still in the process of completing our most recent OCS resource assessment, we are unable at this time to provide the Subcommittee with a detailed discussion of our results or conclusions. At this stage, we are still extensively reviewing data and outputs based on the methodology and assumptions we have employed to conduct the assessment. However, please be assured that as soon as the results are finalized we will promptly share them with the Subcommittee. Further, should you so desire, we will be pleased to provide an in-depth briefing on these results and their underlying assumptions to any interested Members or staff.

Conclusion

In conclusion, we believe our current resource assessment methodology, and thus the resulting information, will be far superior to previous MMS assessments and look forward to a peer-review of the geologic, engineering and economic data and assumptions used in the assessment. We also believe that the extensive amount of materials to be released through our regional reports and the format of such reports will more readily meet the needs of the extensive public and private audiences for such information--thereby contributing to efforts to develop balanced resource management policies with regard to OCS resources. While reliable resources estimates are only one of many factors to be considered when making OCS resource management decisions, they are an important component and should be based on high quality science. We are

confident that our new methodology will produce results that meet that high standard.

Mr. Chairman, this concludes my prepared remarks. However, I will be pleased to answer any questions which Members of the Subcommittee may have.

STATEMENT OF

DAVID MOREHOUSE

SENIOR PETROLEUM GEOLOGIST

ENERGY INFORMATION ADMINISTRATION

DEPARTMENT OF ENERGY

before the

SUBCOMMITTEE on ENERGY AND MINERAL RESOURCES

of the

COMMITTEE on RESOURCES

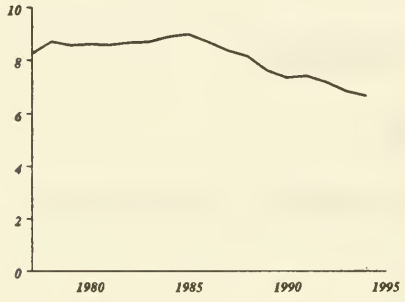
UNITED STATES HOUSE OF REPRESENTATIVES

MARCH 21, 1996

Mr. Chairman and Members of the Committee:

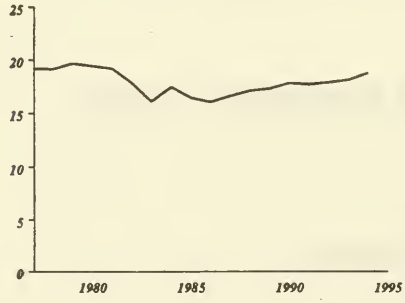
I appreciate the opportunity to appear before you today to discuss domestic oil and gas resources, proved reserves and production, and the Energy Information Administration's (EIA) efforts to track, analyze and project them. I will cover (a) recent trends in the domestic production and proved reserves of crude oil, natural gas liquids and dry natural gas, (b) the linkage and implications of the EIA proved reserves program's outputs to and for the assessment of undiscovered domestic oil and gas resources, and (c) EIA's projection of the extent to which domestic oil and gas supply, as opposed to imports, will satisfy the Nation's energy demand through 2015, which in part depends on the volume and characteristics of the estimated remaining oil and gas resource base. Before continuing, I'd like to note that EIA is an independent agency of the Department of Energy charged with providing objective data, analyses and forecasts relative to energy matters. EIA does not take a position on any policy proposal and is free to disseminate that which it believes to be true and informative.

Figure 1. Crude Oil Production, 1977-1994 (million barrels per day)



United States crude oil production peaked in October 1970 at a rate of 10 million barrels per day. While oil production on occasion rose a bit from year to year, over the 1977 through 1995 period it declined overall at an average rate of 95.6 thousand barrels per day per year, or almost 1.2 percent per year (Figure 1). If the liquids extracted by natural gas processing plants are included, total petroleum liquids production also decreased in the same period, though at a lesser average rate of 87.2 thousand barrels per day per year or 0.9 percent per year. Domestic production of dry natural gas peaked in 1973 at 21.73 trillion cubic feet, declined to a post-1966 low of 16.09 trillion cubic feet in 1986, and then increased, though not in every year, to 18.72 trillion cubic feet in 1995 (Figure 2).

Figure 2. Dry Natural Gas Production, 1977-1994 (trillion cubic feet per year)



The production statistics I have cited for crude oil, natural gas liquids, and natural gas are developed monthly by the producing States and the Minerals Management Service. Accurate and verifiable estimates of the proved oil and gas reserves from which production comes

have been generated annually since 1977 by EIA. These estimates are survey based and they require nine months to produce, so the most recent EIA proved reserves estimates are for December 31, 1994. Proved reserves are those quantities which geological and engineering data demonstrate with reasonable certainty to be recoverable in the future *from known reservoirs under existing economic and operating conditions*. They are estimates, not precise quantities. Their quality depends on the amount and kind of data available to, and the professional judgement of, the estimator. There are substantial aggregate year-to-year proved reserves changes. For example, for crude oil, U.S. proved reserves increased 6 percent in 1991, Texas' declined 8 percent in 1986, and Wyoming's declined 9 percent in 1994. Information regarding the EIA reserves program is included for reference as Exhibit A, appended at the end of my written statement. While I'll not cover it orally, I'll be pleased to answer any questions you have about the program.

Figure 3. Crude Oil Proved Reserves, 1977-1994 (billion barrels)

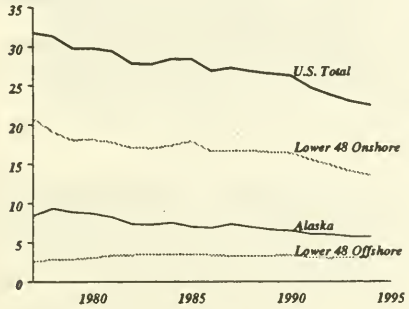
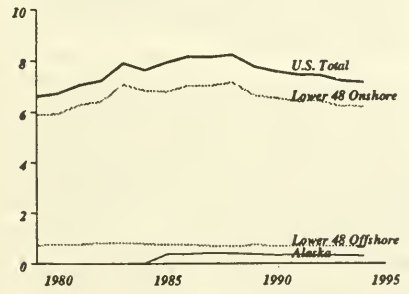


Figure 4. Natural Gas Liquids Proved Reserves, 1979-1994 (billion barrels)



Domestic proved reserves of crude oil generally declined over the 1977 to 1994 period, from 31.78 billion barrels to 22.46 billion barrels, 29.3 percent overall and an average of 1.7 percent per year. This is illustrated in Figure 3 which also indicates the component proved reserves estimates for major geographic areas. Proved reserves of natural gas liquids, representing lease condensate and the liquefiable content of produced gas that is stripped at downstream natural gas processing plants, were 6.62 billion barrels in 1979. They increased 24.5 percent to 8.24 billion barrels in 1988 and then decreased 13 percent to 7.17 billion barrels in 1994 (Figure 4). The 1977 to 1988 increase was primarily due to addition of new gas processing capacity, improved technology and an increase in recovery of light components such as ethane and propane. Proved reserves of dry natural gas, when adjusted prior to 1988 by the removal of 24.6 trillion cubic feet of proved reserves located in Alaska's Prudhoe Bay Field which were de-booked for economic reasons in that year, as shown in Figure 5, were 182.81 trillion cubic feet in 1977 and decreased only 10.4 percent to 163.84 trillion cubic feet in 1994, a 0.6 percent per year

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Figure 5. Dry Natural Gas Proved Reserves, 1977-1994
(trillion cubic feet)

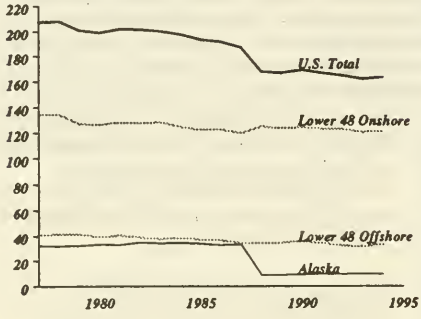
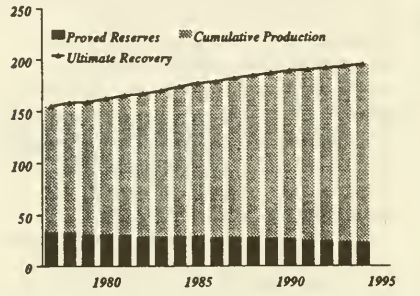


Figure 6. Components of Ultimate Recovery for Crude Oil and Lease Condensate, 1977-1994
(billion barrels)



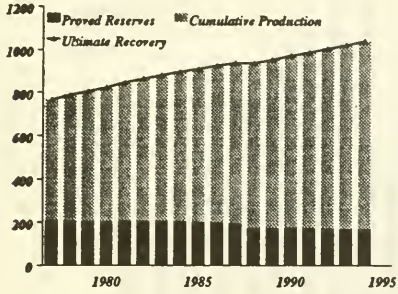
decline rate. Internationally the United States ranks eleventh in crude oil proved reserves behind each of five Persian Gulf countries, the former USSR, Venezuela, Mexico, Libya and China. It ranks sixth in natural gas proved reserves, behind the former USSR and each of four Persian Gulf countries.

Estimated ultimate recovery from the Nation's discovered oil and gas resources is defined as the sum at a point in time of all production to that time and the estimate of proved reserves at that time. Figures 6 and 7 show the steady growth of domestic estimated ultimate recovery from 1977 through 1994 for crude oil and wet - not dry - natural gas, respectively. Notice the generally decreasing portion accounted for by proved reserves in both instances.

That, then, is the general proved reserves and production picture for the United States over the recent past. It reflects slowly decreasing domestic proved reserves and production of crude oil and natural gas liquids, and decreasing, though at a lesser rate, proved reserves of natural gas. We may be at a turning point for natural gas in that the number of exploratory gas well completions has been increasing since 1992, gas production (excepting 1991) has been increasing since 1986, and proved gas reserves managed to follow suit in 1994.

I turn now to the subject of undiscovered resource estimation, and the linkages between EIA's reserves work and others' resource estimation work. As described in more detail in Exhibit A, EIA collects estimates of proved reserves by field from the larger operators of domestic oil and gas wells. A reservoir is the natural unit of occurrence of liquid and gaseous hydrocarbons in the subsurface; a field consists of one or more reservoirs grouped on or related to an individual structural or stratigraphic condition. The largest operators are required to file proved reserves estimates by field. And, while intermediate size operators are required to do so only if they maintain such estimates, most do. Together these two groups of operators accounted for 92.6 percent of domestic crude oil proved reserves and 94.2

Figure 7. Components of Ultimate Recovery for Wet Natural Gas, 1977-1994 (trillion cubic feet)

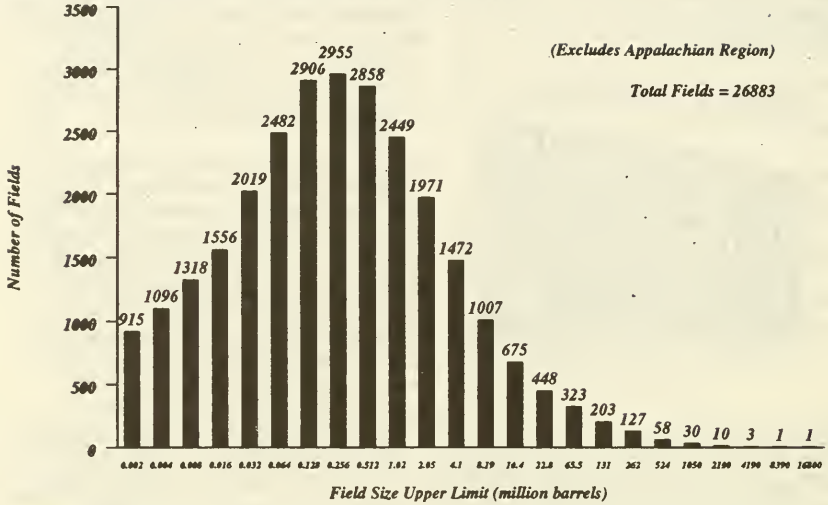


percent of domestic proved reserves of dry natural gas as of December 31, 1994. Thus, through its survey, EIA has obtained a fairly complete picture of the United States proved reserves situation at the field level of estimate aggregation over a period of 18 years.

EIA has accurately combined the available reserves estimates field-by-field with correlative production data obtained from State sources and the Minerals Management Service to create its Oil and Gas Integrated Field File (OGIFF). While the file contains proprietary data and therefore is not releasable to the public, alone and in conjunction with additional geologic and engineering data it provides the basis for useful analyses of many kinds. For example, EIA publicly provides a derivative product which presents estimates of proved reserves and production aggregated by county or parish in those instances where the number and relative sizes of the reporting operators precludes the identification of an individual respondent's estimate; this product is very popular with industry and academia. We have published, and will periodically reissue as sufficient new data accumulates, reports on the largest United States fields and on reserves by year of field discovery. These data provide more detail than is available in the annual reserves report series without disclosing individually identifiable reserves estimates. And the OGIFF is a key input to ultimate oil and gas resource estimation as respects both undiscovered fields and projection of the appreciation over time of ultimate recovery from known fields, sometimes referred to as "field growth".

Estimation of ultimate recoverable resources, no matter what technique or procedure is used, applies what we have learned about oil and gas occurrence in thoroughly explored and studied areas to areas in which little or no drilling has yet taken place. Even a simple visual examination of the OGIFF field-level reserves estimates arrayed to form the size distribution of known fields in an area, as we did province-by-province and region-by-region in our report *Geologic Distributions of U.S. Oil and Gas*, based on year-end 1989 data, reveals a great deal about the general prospects of that area. For example, Figure 8 shows the field size distribution for all U.S. crude oil fields. It is a classic example of the distribution for an area in which exploration is mature. It is smooth, it is positive skew, and it is approximately negative exponential to the right of the mode (the peak), reflecting the well established fact that in the vast majority of sufficiently large and prospective geographical areas, there are only a few large fields whereas there are many quite small ones. The logarithmic size scale used here compresses the distribution so that the long right tail is not so obvious, or paper consuming, as it would be if the scale were linear. The roll-off to the left of the mode is due to truncation of the real, physical field size distribution by economic conditions, i.e., it is an

Figure 8. Size Distribution of Oil Fields in the United States



observational artifact. Newly discovered fields that are too small to be economically produced do not, by definition, ever have proved reserves, so their discovery remains in effect unreported.

As evidenced by their field size distributions, most prospective continental United States regions are at or approaching exploration maturity. An example is the distribution for Mid-Continent Region crude oil fields (Figure 9) which is close to, but not quite as mature as, the U.S. distribution. Typical new field discoveries in such areas can confidently be expected to be relatively small. On the other hand there are three regions of the country in which exploration is clearly immature for both oil and gas. Figure 10 is the observed crude oil field size distribution for the Far West Region which includes prospective geologic provinces that lie onshore and offshore of Washington, Oregon and California, in Idaho, and in parts of Nevada and Utah. The most prospective component of this group is onshore and offshore California. Figure 11 is the observed crude oil field size distribution for onshore and offshore Alaska. Both region's field size distributions are considerably less than smooth and a clear positive skew has yet to develop -- because they are immaturely explored. The same situation pertains for oil and gas in the Gulf of Mexico, particularly along the continental slope and in deep water. These three regions are the places where undiscovered oil and gas resources remain to be found that are sufficiently large to be of long term national supply significance, as opposed to only local commercial significance. A possible fourth, the Atlantic offshore, could not be addressed in our study as no fields have yet been found; it appears to be primarily gas prone. The findings of the EIA

Figure 9. Size Distribution of Oil Fields in the Mid-Continent Region

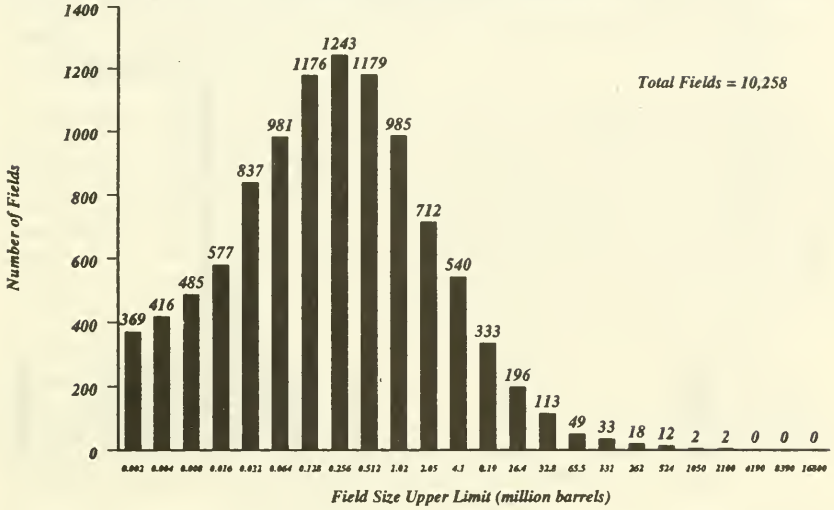


Figure 10. Size Distribution of Oil Fields in the Far West Region

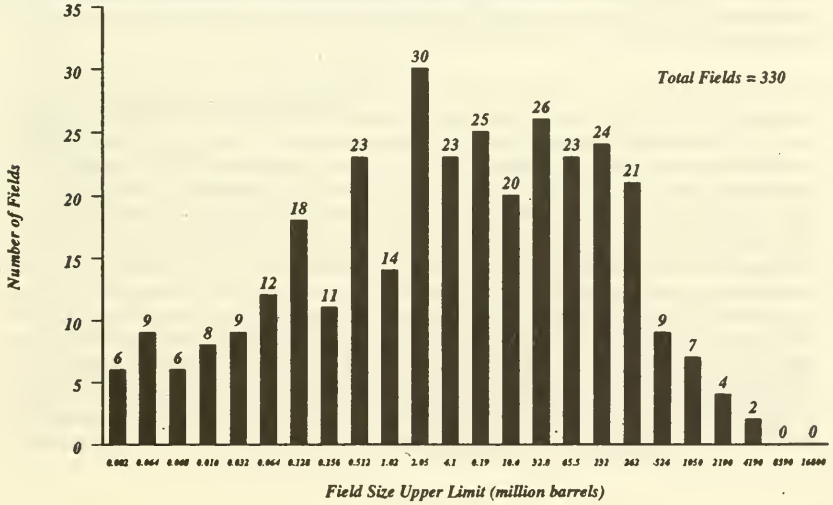
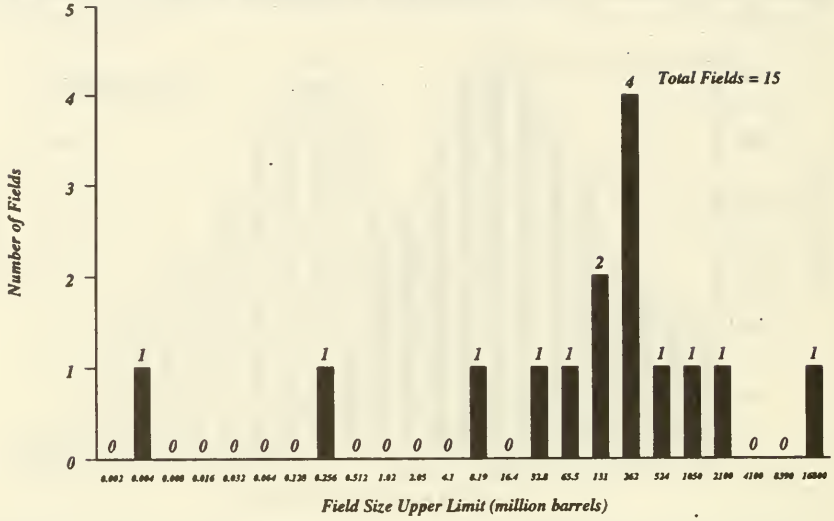


Figure 11. Size Distribution of Oil Fields in the Alaskan Region



field size distribution study are confirmed by the results of the much more detailed and thorough United States Geological Survey and the Minerals Management Service oil and gas resource estimation programs, and by the biennial gas resource estimates produced by the industry-based Potential Gas Committee.

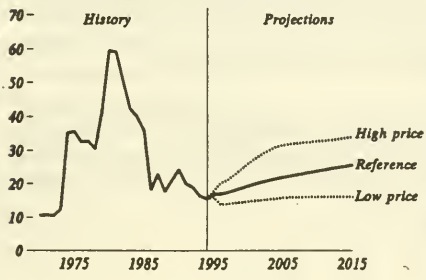
The estimated ultimate recoveries of most oil and gas fields are observed to appreciate, often very substantially, subsequent to the time that initial estimates of their proved reserves are booked; the rate of increase typically decreases over time. There are a number of reasons why this occurs, the most important being that while a discovery well may alone be sufficient to indicate presence of a commercially producible reservoir, it cannot reveal its full extent or adequately characterize its degree of heterogeneity. Consequently initial proved reserves are usually only booked, particularly in the United States, for a limited radius around the discovery well. As additional drilling and actual production operations further delineate the reservoir's boundaries and provide more information about its characteristics, additional proved reserves are then booked. Other factors, such as the introduction of more productive technology, an increase or decrease of oil or gas price relative to costs, and a firm's institutional booking practice also can affect the rate at which known fields are observed to "grow" through time. Over the past 17 years, 93.6 percent of additions to domestic proved crude oil reserves and 86.3 percent of additions to domestic dry natural gas reserves have been due to ultimate recovery appreciation as reflected in net positive revisions and adjustments to previously booked proved reserves, additions to proved reserves due to the extension of proved

reservoir area and the discovery of new reservoirs in known fields. Discovery of new fields accounts for the remainder, less than 15 percent in both instances. Clearly, it is very important when projecting the ultimately recoverable resource, and therefrom future production possibilities, to understand the ultimate recovery appreciation phenomenon well.

The estimates of ultimately recoverable resources generated in the Department of Interior National Assessment that was based on year-end 1986 data relied in part on an annual series of ultimate recovery estimates for known fields generated from 1946 through 1979 by the American Petroleum Institute and the American Gas Association. These were aggregates by State and bore no underlying relation to petroleum geology ... but they were the only such data available at that time. Upon creation of the far more detailed EIA OGIFF in 1989, a Memorandum of Understanding was signed between EIA and the United States Geological Survey (USGS) that both allows the Survey to use the file and maintains its confidentiality. As a result, the most recent USGS assessment for the onshore United States and adjacent State offshore waters, based on data available at year-end 1993, reflects an expected addition to proved reserves over the next 80 years of 60 billion barrels of crude oil, 13.4 billion barrels of natural gas liquids, and 322 trillion cubic feet of natural gas. These quantities are 184 percent more for crude oil, 253 percent more for natural gas liquids, and 247 percent more for natural gas than those estimated in the prior National Assessment. That is not the end of the road insofar as analysis of the ultimate recovery appreciation phenomenon is concerned.. As yet, no comprehensive mechanistic analysis of the phenomenon has been done, and one must be if we wish to validate, and perhaps improve, our ultimate oil and gas resource estimates.

I now turn, with emphasis on oil and gas, to EIA's projections of the Nation's energy future through 2015, as presented in the *Annual Energy Outlook 1996* (AEO96). The AEO96 projections are in part predicated on the most recent oil and gas resource assessments produced by the USGS, the MMS, the National Petroleum Council (for gas) and the Department of Energy's Office of Fossil Energy. I hasten to add that I am not involved with EIA's forecasting programs and may not be able to answer some questions you may have about them.

Figure 12. World oil prices in three cases, 1970-2015
(1994 dollars per barrel)



The Cases

The reference case *AEO96* forecast for the world oil price in 2015 is $25.43 per barrel (Figure 12). The recent historical record shows substantial variability in world oil prices, and there is corresponding uncertainty about future prices. Two additional cases with alternative projections of prices are presented to reflect such uncertainty. In the low world oil price case, oil prices drop below current prices for the next few years and then gradually return to current levels, where they remain throughout the forecast. In the high world oil price case, prices increase to $32.61 per barrel in 2010, continuing to $33.89 in 2015.

Figure 13. Domestic oil supply, consumption, and imports, 1970-2015 (million barrels per day)

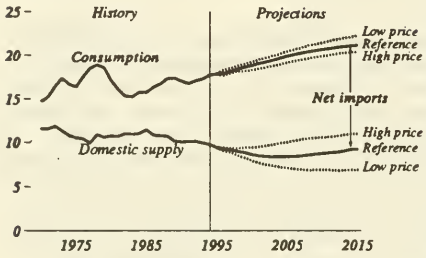
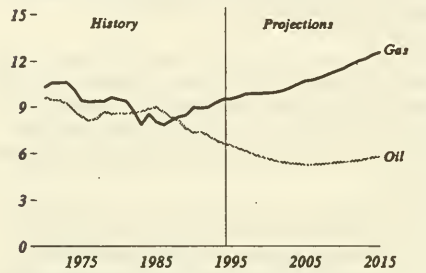


Figure 14. Natural gas and crude oil production, 1970-2015 (million barrels oil equivalent per day)



Net imports of both oil and gas grow to fill the difference between domestic supply and consumption (Figure 13). In the reference case, the growth in net natural gas imports from 12 percent of total gas consumption in 1994 to 14 percent in 2015 is far less than the growth in net oil imports from 45 percent of oil consumption in 1994 to 56 percent in 2015. When high world oil prices are assumed, little change is expected from the current balance between domestic and foreign oil supply, and continued low prices could lead to an import share as high as 68 percent in 2015.

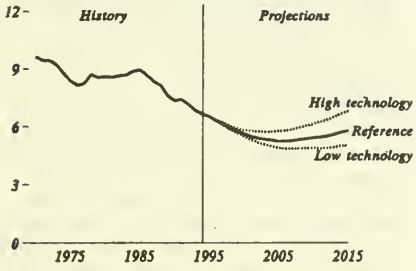
Supply

In the reference case, U.S. oil production declines over the project period. The projection for domestic crude oil production declines by 21 percent from 1994 to 2005 as depletion of domestic oil resources continues (Figure 14). From 2005 to 2015 production increases by 11 percent as prices rise, stimulating overall drilling, and the cumulative effects of improved technology extend development efforts to more costly resources. In 2005, estimated domestic oil production is projected to bottom out at 5.3 million barrels a day, rising to 5.8 million barrels a day in 2015.

Driven primarily by growth in consumption, natural gas production increases at an average annual rate of 1.3 percent between 1994 and 2015. Expanded production over time reflects the combined impact of slightly rising prices, relatively more abundant natural gas resources, and improvements in technologies, particularly for unconventional gas recovery and offshore projects. Imports of gas, mostly from Canada, satisfy some of the increase in demand. Canadian producers are projected to gain market share over the forecast period as net natural gas imports expand from 12 percent of total gas consumption in 1994 to 14 percent in 2015.

Key assumptions have significant effects on the projections. For example, changing the assumed rates of technological improvement applied to exploration and development costs, resources, and drilling success by plus or minus 50 percent results in a significant variation in projected crude oil production (Figure 15). In 2015, crude oil production differs by more than 27 percent between the low and high technology cases.

Figure 15. Crude oil production in three cases, 1970-2015
(million barrels per day)



To support the higher projected levels of natural gas production and as required to develop less attractive crude oil prospects, oil and gas drilling levels are projected to increase in the forecast. With rising prices and generally declining drilling costs, crude oil and natural gas well completions grow at average annual rates of 6.7 and 4.5 percent, respectively (Table 1).

Natural gas drilling is projected to be more productive than oil drilling in terms of total production and production per well in barrels of oil equivalent, in part because our remaining recoverable gas resources are more abundant than our oil resources. The future productivity of both oil and gas drilling is uncertain to the extent that the Nation's oil and gas resources are uncertain.

Table 1. Natural gas and crude oil drilling in three cases
(thousands of successful wells)

	1994	2000	2010	2015
Natural gas				
Low oil price case		10.5	15.2	20.3
Reference case	8.9	11.3	16.1	22.3
High oil price case		12.5	17.3	24.7
Crude oil				
Low oil price case		6.8	10.9	18.4
Reference case	6.8	10.8	21.5	36.5
High oil price case		19.7	30.5	53.4

In the high and low oil price cases, oil drilling shows greater variation than gas drilling because the wellhead price of domestic oil responds more strongly to changes in the world oil price.

Higher drilling levels lead to significant increases in annual reserve additions. Lower 48 natural gas reserve additions rise at an average annual rate of 0.8 percent over the 1994-2015 period, continuing the overall trend of the past two decades. Lower 48 oil reserve additions increase at about 2.0 percent per year over the projection period, reversing the generally declining trend of the past two decades.

Natural gas reserve additions more than offset production between 1998 and 2007. Lower 48 gas reserves peak at more than 164 trillion cubic feet in 2007, then decline to 162 trillion cubic feet by 2015, reflecting the fall in conventional onshore reserves. Despite the projected increase in oil reserve additions, production exceeds additions in most years. Oil reserves decline at a rate of 1.0 percent a year. In the high and low oil price cases, oil and gas reserve additions also rise throughout the forecast period; the decline of oil reserves is reversed in the high price case (Table 2).

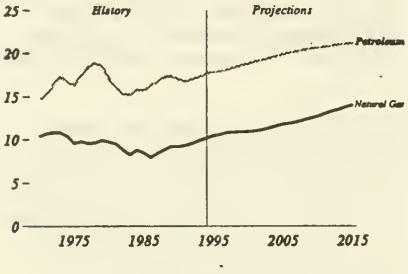
Table 2. Lower 48 natural gas and crude oil reserve additions in three cases
(billion barrels oil equivalent)

	1994	2000	2010	2015
Natural gas				
Low oil price case		3.48	3.74	3.83
Reference case	3.58	3.81	3.94	4.19
High oil price case		4.24	4.05	4.38
Crude oil				
Low oil price case		0.70	1.15	1.80
Reference case	1.33	1.18	1.91	1.99
High oil price case		1.94	2.49	3.32

Demand

Natural gas consumption increases at an average annual rate of 1.6 percent per year, from 20.8

Figure 16. Energy consumption by source, 1970-2015
(million barrels per day oil equivalent)



trillion cubic feet per year in 1994 to 28.7 trillion in 2015(Figure 16). The 1972 historic high of 22.1 trillion cubic feet is exceeded in 1997, after which consumption increases steadily through 2015. Growth is seen in all sectors, particularly the electricity generation sector where consumption doubles by 2013 and continues to grow through 2015. Much of the growth in natural gas use for electric power generation after 2010 is highly dependent on the expected retirement of aging nuclear generation capacity which is assumed to retire at the end of the current operating license in the reference case. Should these units retire 10 years before their operating license expiration dates, annual natural gas consumption in the power generation sector is projected to increase by about 1 trillion cubic feet as compared to the reference case by 2015. Alternatively, should these units operate for a period of 10 years longer than their operating license, annual natural gas consumption for electric power generation is projected to be about 1.2 trillion cubic feet less than the reference case in 2015. Gas use in the residential, commercial, and industrial sectors grows more slowly, at 0.5, 0.7, and 1.1 percent a year, respectively, through 2015. These growth rates compare to a 3.9 percent average growth rate for natural gas use in electric power generation.

Petroleum consumption grows at a slower pace (0.9 percent a year) than for natural gas but exceeds its historic high (18.8 million barrels per day in 1978) toward the turn of the century, primarily due to increased transportation demand. Ninety seven percent of U.S. transportation energy is supplied by petroleum; this represents almost two-thirds of all U.S. petroleum consumption. The reference case projects petroleum consumption for transportation use will rise from 1994 levels of 11.50 million barrels per day to 14.29 million barrels per day by 2015. There is an almost equal contribution from distillates (0.8 million barrels per day), motor gasoline (0.9 million barrels per day), and jet fuel (0.7 million barrels per day).

Gasoline consumption is projected to continue to rise through 2015 because of low projected prices which result in slower gains in fuel economy and an increase in vehicle-miles traveled. Distillate fuel consumption is also projected to increase above 1994 levels because of low prices which lead to a much slower gain in fuel economy for freight trucks. Jet fuel consumption is projected to also rise rapidly through 2015 as low prices result in fewer fuel efficiency gains for new aircraft and a rapid rise in air travel.

Environmental concerns have led to Federal, and some State, legislative mandates for the use of alternative-fuel vehicles. Sales of alternative-fuel vehicles rely on these mandates until 2001, as market-driven sales of alternative-fuel vehicles do not appear in large numbers until then, after the expected emergence of a functional supporting infrastructure. In 2015, market-driven alternative-fuel vehicle sales are projected to approach about one million units, with the majority using

alcohol-based fuels. Total sales of alternative-fuel vehicles are projected to be about 1.7 million units, or 9.7 percent of all vehicle sales in 2015.

Thank you for the opportunity to testify about the Nation's oil and gas resources, reserves and production and their implications for the future. I'll be happy to take any questions you may have.

EXHIBIT A. The EIA Oil and Gas Reserves Program

In the wake of the 1973 oil embargo and Congressional distrust of the estimates of domestic oil and gas reserves estimates prepared since 1946 by the oil and gas industry, an initial task assigned to the fledgling Energy Information Administration (EIA) was creation of an accurate, continuing domestic oil and gas reserves estimation program. Authorized under the Department of Energy Organization Act of 1977 (Public Law 95-91) and the Federal Energy Administration Act of 1974 (Public Law 93-275), this work followed on the heels of the Federal Power Commission's (FPC) ground-breaking annual survey of the gas reserves of jurisdictional producers, begun in 1976, and a one-time survey of domestic oil and gas reserves conducted by the Federal Energy Administration as part of Project Independence Blueprint in 1975. The EIA reserves program began in 1977, staffed by personnel transferred from the FPC program, which was terminated. Progress was interrupted for more than a year by a legal challenge, but by the end of 1981 annual reserves data for 1977 through 1980 had been collected, processed, corrected, and translated into national and regional proved reserves estimates. Altogether EIA has published 18 sets of annual estimates and is working on the nineteenth.

The largest operators of domestic oil and gas wells, those that annually produce 1.5 million barrels or more of crude oil or 15 billion cubic feet of natural gas or both, now report their estimates of beginning- and end-of-year proved reserves, and changes during the year by type of change, by field. In 1994, there were 155 large operators that accounted for 87.5 percent of proved crude oil reserves and 83.6 percent of proved natural gas reserves, wet after lease separation. Proved reserves are those quantities which geological and engineering data demonstrate with reasonable certainty to be recoverable in future years from known reservoirs under existing economic and operating conditions. There are additional technical conditions it's not necessary mention here. Note that proved reserves are reasonable estimates, not precise or certain quantities. The latter can only be known after a reservoir has been produced to permanent abandonment. The quality of reserves estimates depends on the kind and amount of data available to the estimator, and their formulation involves the application of professional judgement.

Intermediate size operators, those that produce less than the large operator lower limit but at least 400,000 barrels or crude oil or 2 billion cubic feet of natural gas or both, also file their reserves estimates by field. However, in the interest of burden reduction, if they do not have estimates for a particular field they are only required to file field identity, location and production data. Reserves for the operator's portion of such a field are then statistically imputed by EIA. In 1994 there were 471 intermediate size operators that accounted for 5.1 percent of proved crude oil reserves and 11.6 percent of proved natural gas reserves, wet after lease separation.

Small operators, by far the most numerous, are those that produce less than the intermediate operator lower limits. They are only required to provide annual production data by State or State subdivision within some States; they may also provide reserves estimates if they have them. These operators are divided by EIA into two strata which change a bit at their joint margin from year to year for statistical reasons. The first stratum is sampled with certainty. In 1994 it consisted of (a) those small operators that produced 200,000 barrels of crude oil or 1 billion cubic feet of natural gas or more, or that had proved reserves of 4 million barrels of crude oil or more or 20 billion cubic feet of gas or more; (b) all other operators with reserves or production exceeding State or State subdivision cutoff levels statistically established by EIA; (c) the largest operator in each State or

subdivision regardless of the level of reserves or production; and (d) operators with production or reserves of crude oil or natural gas located in six or more States or State subdivisions; in 1994 there were 1,656 small operators in the certainty stratum. The second stratum consists of all remaining small operators, 20,517 of them in 1994. It is randomly sampled at an 8 percent rate. The reserves of all small operators that did not provide reserves estimates are statistically imputed from their production by EIA. In 1994 the small operators accounted for 7.4 percent of proved crude oil reserves and 5.9 percent of proved natural gas reserves, wet after lease separation.

Response to the 1994 reserves survey was 100 percent for all but the randomly sampled stratum of small operators, for which the response was 99.5 percent. These response rates are typical. The U.S. proved reserves estimates for crude oil and natural gas are associated with sampling errors of less than 1 percent at the 95 percent confidence level.

Additionally, EIA surveys the active natural gas processing plants in the United States (there were 791 of them in 1994) to determine their liquids extractions by the State of origin and volume of their inlet streams. These data, combined with the estimated lease condensate proved reserves and production data collected in the reserves survey, allow estimation of natural gas liquids proved reserves and production by State and State subdivision. EIA also utilizes a postcard survey to maintain the operator sampling frame for the reserves survey as many operators, particularly small ones, go into and out of business or merge during any given report year.

The EIA reviews the reserves estimates of selected operators and fields annually. Our petroleum engineers and geologists have complete access to the operator's records in their offices, including making independent estimates of their reserves. We also compare the reserves estimates submitted by Federal Outer Continental Shelf operators to reserves estimates independently prepared by the staff of the Minerals Management Service, in order to reconcile them whenever possible and to understand the cause of difference if not. In the latter case there is usually a legitimate difference of interpretation regarding the local geology, given the available data.

The reserves program was initially staffed with 10 full time equivalent (FTE) Federal employees. The 1994 survey was staffed with 6 FTE Federal employees. In constant dollars, the contract costs associated with the 1994 reserves program were reduced about 50 percent below those of 1984, without sacrifice of quality or timeliness (and output, in terms of the analyses and reports based on the reserves data, has increased). Nevertheless the reserves program remains one of the largest line items in EIA's internal budget; while this sort of work can be done efficiently, it cannot be done cheaply.

Outputs from the EIA oil and gas reserves program in the form of:

the annual reserves report series,

a series of technical reports that usefully analyzes field level reserves data in conjunction with related data while preserving confidentiality of respondent's individual reserves submissions, and

special studies conducted for the Congress, the Department of Energy, and other Executive agencies,

are relied upon by all levels of government, the oil and gas industry, energy analysts and forecasters, and the finance industry. In part that is inevitable because EIA is the only source of comprehensive domestic oil and gas reserves information. Far more important, however, is the fact that the EIA reserves program's products are highly regarded. For example, a 1985 National Academy of Sciences review noted that the reserves survey is conducted in a "scientifically sound and effective manner", that it is one of the rare government survey programs that "... has general industry approval," and that the "EIA Annual Reserves Report is a unique national resource." The program truly produces information about the Nation's proved oil and gas reserves that is comprehensive, accurate, verifiable, timely and continuing, exactly as intended.

TESTIMONY OF
DAVID O. WEBB, SENIOR VICE PRESIDENT
POLICY AND REGULATORY AFFAIRS
GAS RESEARCH INSTITUTE
BEFORE THE
HOUSE COMMITTEE ON RESOURCES
MARCH 21, 1996

Gas Research Institute (GRI) appreciates the opportunity to testify at this hearing regarding the state of the natural gas industry. The gas industry has experienced significant changes over the past decade due to both deregulation of segments of the industry and the changes in the business structure of the gas industry. As the gas industry has adjusted to the new business environment, we have seen dramatic changes in the way the industry does business. Old "rules" no longer apply, and in many cases, new "rules" do not exist to replace them. We are working in an environment which continues to evolve under a far different structure than existed even 10 years ago.

GRI is the research, development and demonstration (RD&D) management organization of the natural gas industry. Our mission is to discover, develop, and deploy technologies and information that measurably benefit gas customers and enhance the value of gas energy service.

INTRODUCTION

Despite a decline of one-third in average wellhead gas prices and a reduction of 50 percent in drilling levels since the mid-1980s, U.S. gas production has increased 28 percent, and total supplies have met increasing levels of demand. The ability of producers to meet increasing U.S. demand despite reduced drilling levels has resulted from both technological advances and industry practices and strategies that have increased efficiency, reduced costs, and expanded the recoverable resource. As a result, overall costs of finding and developing gas in the United States have declined significantly.

THE SUPPLY OUTLOOK

In its latest *Baseline Projection of U.S. Energy Supply and Demand*, GRI estimates total gas demand will grow from 21.4 quads [20.8 trillion cubic feet (Tcf)] in 1994 to 29.3 quads (28.4 Tcf) in 2015 or at 1.5 percent per year. While this represents a significant level of growth, it is important to note that the gas share of total energy consumption only increases from about 24 percent in 1994 to just over 26 percent by 2015. The largest segment of this growth is expected to occur in the industrial sector, which is expected to grow from 9.5 quads in 1994 to more than 12 quads by 2015. A major source of this growth is increased demand by cogenerators. However, strong gas demand growth also occurs in process heat applications and as a raw material. Gas demand in the electric generation sector is projected to grow from 3.2 quads in 1994 to almost 6.5 quads by 2015.

Through the mid-1980s, gas decisionmaking focused on maintaining existing markets. new markets were not an option. In large part, this focus reflected the outlook for gas supply. Gas prices were expected to have to grow rapidly to even maintain current gas supply, thus putting many existing markets at risk as well. Gas transmission and distribution charges were also expected to increase, thereby increasing the competitive risks to gas sales. Through the mid-1980s these expectations appeared to be borne out.

Since the mid-1980s, there has been a sea change in the gas supply and price outlook. Since 1986, U.S. gas supplies have increased almost 30 percent. In 1994, U.S. gas supply was the highest it had been since 1974. Supply has grown even though gas prices are more than one-third lower than their peak in 1983 on a nominal basis and more than one-half lower on a real dollar basis.

The extraordinary success of the gas industry in expanding gas supplies and maintaining adequate deliverability under the low prices of the last decade can be attributed primarily to the development and deployment of new technologies that have increased supply additions per unit of effort. Reported reserve additions per new gas well since 1986 is about double the average level over the previous decade. Highly productive new sediments and plays have made significant additions to U.S. production. The abandonment rate of producing gas wells has been cut more than one-half, reflecting in part the increased role of recompletions. Real drilling charges for gas wells have declined 31 percent since 1985, although their average depth has increased 15 percent. Historically, success rates have generally declined with drilling depth, but since 1988 that has begun to change.

RESERVE ADDITIONS PER WELL AND COMPLETION

Recovery per well is a good measure of industry's ability to efficiently discover and develop new reserves. The usual method of evaluating recovery per well employs annual nonassociated reserve addition data compiled by the Energy Information Administration and annual new gas well counts compiled by the American Petroleum Institute. These data indicate that since the mid-1980s, recovery per well nationally has averaged about 1.5 billion cubic feet (Bcf)--about 90 percent above the average of the previous 10 years.

The almost doubling of recovery per well has been driven by increased recovery per completion and a growing share of recompletions. Improved recovery per completion has been the primary factor and has resulted from both improvements within regions and from movement by industry to more productive regions and depth intervals.

DRILLING SUCCESS RATES

Historically, onshore lower-48 success rates have generally declined with depth and through the late 1980s this was the case. Since 1988, this trend has changed. Success rates now show a general upward trend with increasing depth.

While this change had only a modest impact on overall onshore success rates, improving them from 69 to 75 percent in 1994, the sharp increase in success rates with

depth since 1988 has reduced the risk of deeper drilling in onshore areas and has been a major contributing factor in the shift of activity to deeper targets. Reported drilling activity for the first two quarters of 1995 suggests that the shift to deeper drilling is continuing, particularly below 10,000 feet. Increased success rates for deeper wells also have had a substantial effect on the share of total drilling expenditures for dry holes. In 1988, 25 percent of onshore drilling expenditures were for dry holes, while in 1994, the dry hole fraction is estimated to have declined to 18 percent or less.

New technology has played a major role in the improved success rates. Technology effects include the use of 3-D and advanced 2-D seismic, improved geological and engineering data acquisition and interpretation, and improved drilling and completion technologies. Technology effects also include more widespread and effective use of existing technologies, such as the increased use of seismic data before drilling new wells.

In some areas, directional drilling capabilities are increasingly used as a method of improving success rates by allowing the testing of multiple, laterally separated exploration targets in one well. Using this approach, the probability of an economic discovery is much higher than with a vertical well evaluating one target, and the recovery per well is generally much higher. In the first half of 1995, more than one-fourth of U.S. wells were directionally drilled, more than double the share in 1993.

RESERVE GROWTH IN EXISTING FIELDS

Reserve additions in known fields have played an important role in the improved rate of reserve additions since the mid-1980s. These reserve additions are far in excess of what reserve growth estimates through the mid-1980s would have indicated. Current resource estimates for remaining reserve growth potential are much higher and indicate that the recent scale of reserve additions will continue. The current GRI estimate of lower-48 reserves growth potential is 244 Tcf, and the recent USGS estimate indicates that total lower-48 growth potential in discovered fields exceeds 300 Tcf.

Much of the recent reserve growth has been in the Gulf Coast and Gulf of Mexico regions, where the geology is charactenzed by multiple stacked reservoirs, productive intervals up to several thousand feet thick, complex faulting, and reservoir heterogeneity. This complex geology results in a wide range of potential intra-field exploration opportunities to discover deeper pools, bypassed reservoirs, or untapped compartments.

Exploration for deeper, more subtle targets has been made possible through recent advances in seismic technologies. New geological concepts and improved engineering data and models are allowing operators to target untapped compartments in productive intervals. New completion techniques, including horizontal drilling and improved fracture design, have resulted in improved recovery per completion. Exploratory and development opportunity exists in essentially every large field, and exploration for deep reservoirs and bypassed compartments using new technologies is still in its early stages.

Higher reserve growth potential in current fields also implies greater potential in undiscovered fields. Because estimates of conventional undiscovered potential are

generally based upon analysis of the size distribution of fields discovered by increments of past exploratory drilling, increased recovery from historical fields means that new discoveries should be larger as well.

NONCONVENTIONAL GAS

Advanced completion and stimulation technologies and reduced costs have allowed increased economic development of tight reservoirs, coalbed methane, and shale. Such nonconventional reservoirs now contribute significantly to lower-48 gas production and proven reserves, and large-scale undeveloped resources are present. Nonconventional gas production has increased in recent years despite low gas prices and the phasing out of tax incentives. Almost all of the coalbed methane development and production increases have occurred since the mid-1980s. The primary reason for this is that prior to the 1980s, production technology and understanding of the coalbed methane resource were inadequate to encourage significant economic development. While nonconventional drilling tax incentives were a significant factor in the increased drilling levels of the early 1990s in areas such as the San Juan Basin, the underlying trend is one of improved economics resulting from higher well recoveries and reduced costs.

One of the major changes in industry activity over the last decade has been the increasing role of low-permeability gas completions. Through the mid-1980s, such activity was largely confined to a few "sweet spots." With the recent significant advances in reservoir diagnostics, stimulation, and completion technology, industry activity has spread out into the large volumes of tight sands within the boundaries of producing fields.

These recent advances in fracture design for tight sands have reduced costs and improved well performance. For example, the recent fracture design advances developed by GRI have reduced fracture costs 10 to 50 percent and have improved some individual well performance 40 to 300 percent. As these and other technology advances become standard practices, nonconventional gas production should continue to increase.

OFFSHORE GULF OF MEXICO FIELDS

A basic implication of resource depletion is that the best fields are always found early in the exploration history of an area. The offshore Gulf of Mexico has been a significant producing area for about 50 years, a span of time that would qualify the area as being mature. Despite its apparent maturity, significant new discoveries have been made recently. The average recovery per gas well completion in the Gulf of Mexico is higher for the newer fields. The average recovery per completion for fields discovered before 1951 is less than 6 Bcf. The average recovery per completion for fields discovered since 1981 exceeds 8 Bcf. Since both field vintages have about the same number of completions, the data suggest that "quality" of the newest Gulf fields is better than that of the oldest fields.

The relatively stable "quality" of offshore fields since 1951 suggests that activity in the Gulf of Mexico can be considered to have been steadily moving into frontier areas, that is deeper water, instead of only depleting the areas around the initial discoveries.

Given the fact that activity is only just now beginning to become significant in water depths of 1,000 feet or more, yields in the Gulf of Mexico could remain stable or possibly even improve for some time to come.

DEEP GAS

Lower-48 gas activity has been largely confined to the sediments above 10,000 feet. The limited deeper activity reflects a combination of the higher risks and costs associated with deeper drilling and the fact that many deeper prospects are held by good, shallower production and/or prospects. Most gas activity in South Texas has been in the 5,000- to 10,000-foot completion-depth interval. Although the average recovery per completion increases with depth, the increase below 10,000 feet could reflect the limited drilling to date below 10,000 feet.

While it is too early to judge whether the fall-off in quality below 10,000 feet reflects geological or institutional consideration, the data to demonstrate that a shift to activity below 10,000 feet in lieu of activity above 5,000 feet could substantially improve the recovery per completion in South Texas.

ROLE OF UNDERGROUND STORAGE

Although much of the concern for supply capability has focused on wellhead deliverability, the principal focus should be on the interaction between the wellhead and underground storage. The seasonality of natural gas demand causes great swings in customer sendout between winter and summer. Natural gas consumption in January has recently averaged 82 percent more than consumption in August. In addition, the peak winter-day sendout may be as much as 30 percent more than the average for the peak winter month or about 2.4 times the average August sendout. To balance these seasonal loads, the industry relies heavily on underground storage and local peaking supplements.

Increasingly, gas is being produced at the wellhead at high load factors throughout the year, and underground storage is being called on to carry the seasonal variations in load. The heating season of five winter months--November through March--is a time of net storage withdrawals, while the off-peak seven month season is a period of net storage injection.

One important effect of the interaction between supply directly from the wellhead and that from storage is to mask potential problems with inadequate wellhead deliverability. When electric generating capacity is insufficient to meet demand, the effect on customer reliability is direct and immediate. But in an industry where half of peak-day sendout comes from storage and other supplements, a decline in wellhead deliverability simply forces storage withdrawals to absorb a larger portion of the required peak demand. And if cumulative storage withdrawals are too large over the winter period, either because of weather effects or because the wellhead is not carrying its share of the load, storage deliverability levels may be adversely affected. Potential problems with wellhead supply are more likely to manifest themselves as unexpected drawdowns in storage inventories, rather than directly in the form of physical shortages.

This interaction between storage inventories and the supply/demand balance is a common way for gas traders to assess the tightness of the market. An unexpected increase in relative storage inventories means either that expectations about demand were too high or those about supply were too low, and prices for the commodity quickly weaken. Conversely, prices strengthen when storage inventories are lower than expected. Not surprisingly, "storage tracking" has become one of the major activities of gas futures traders on the New York Mercantile Exchange.

The shift in peak supply responsibility from the wellhead towards storage is demonstrably taking place. In 1986, wellhead production operated at an 86.8 percent load factor (measured by the ratio of the peak month relative to the average monthly production for the year). Production during the peak month was 9.0 Bcf/day greater than during the lowest month. By 1993, the load factor had risen to 92.7 percent, and peak-month production was only 4.4 Bcf/day greater than that in the low month.

Storage withdrawals, however, appear to be rising. In 1986, net storage withdrawals averaged 12.0 Bcf/day for the month of January. By January 1991, they had risen to 18.8 Bcf/day, and during the very cold January 1994, they set an all-time high of 26.2 Bcf/day.

IMPACT OF GAS SUPPLY TECHNOLOGY

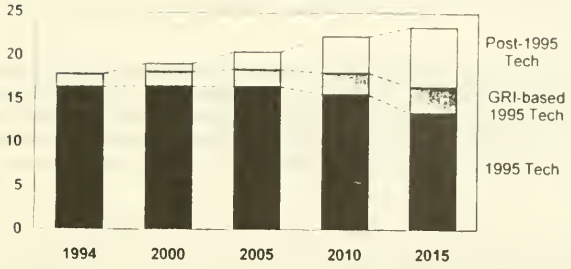
The continued erosion of the prospects for increased gas prices has increased the technical challenges to expand gas supplies on a profitable basis. The natural gas industry must be capable of finding and producing the gas at sufficiently low costs to maintain an adequate profit margin at prices competitive with alternative fuels. Increased operational efficiency and the development of advanced gas supply technologies are the pathways to meeting this challenge.

In GRI's *1995 Baseline Projection of U.S. Energy Supply and Demand to 2010*, the lower-48 gas resource potential increases from about 900 Tcf under 1990 technology premises to almost 1,400 Tcf under 2010 technology premises. Over 40 percent of the increased potential is in new fields, mostly in relatively unexplored, deeper sediments in highly productive lower-48 basins or sediments in deeper waters offshore. About 10 percent is improved recovery from known fields, and nearly 50 percent reflects expanding productive areas or improved recovery of gas-in-place for less conventional formations.

Exploration efficiency is expected to improve at a rate of about 1.5 percent per year between now and the year 2010. Possible advancements in sensor technology and broad technology transfer suggest this level of improvement can be accomplished. Technology must play an essential role in increased U.S. gas supply over the next 20 years. Without any new technology advance, U.S. gas supply cannot be sustained at current levels through the rest of the 1990s. After the year 2000, U.S. gas supply falls off substantially. In the year 2010, U.S. gas supply would be 25 percent lower than it was in 1993. Without any new technology, the U.S. gas industry would wage a losing battle to maintain its 1993 level of gas sales during the rest of the 1990s; after year 2000, gas sales would decline steeply.

TECHNOLOGY EFFECTS ON LOWER-48 GAS PRODUCTION

(Tcf)



GRI Baseline Projection (1996 Edition)

The actual contribution of new technology to gas production will depend on the pace at which the predictability and reliability of new tools, practices, and information can be developed, demonstrated as useful, and transferred to service companies and producers. The low price outlook over the next several years adds urgency to the gas industry and the federal government to make the investment necessary to develop the incremental supply technology and vigorously apply it in the field.

THE ROLE OF THE FEDERAL GOVERNMENT

Over the last decade it has become apparent that new gas supply technological advances have played a major role in the increases in gas reserves and deliverability. These technology advances are the direct result RD&D conducted in the past two decades by federal entities, the gas industry, and joint efforts between the two. RD&D will continue to set the future direction for development and use of our nation's valuable energy resources. Government funds for gas supply research should be continued and used primarily for research not likely to be undertaken unless government provides all or part of the funding. The continuing role of the federal government in funding gas supply RD&D is critical. The government role needs to be clearly defined to allow improved decisionmaking by industry on research priorities as industry competes in an increasingly competitive market.

While federal RD&D should focus on those technologies which are longer-term and/or risky, the gas industry needs to focus on near-term RD&D which will impact its economic well-being. Often, when the roles of the federal government and private industry begin to merge, it provides an excellent opportunity for industry and government to come together to jointly fund those technologies which are of a national interest. In addition, our technical world is becoming increasingly complex. As the cost of RD&D (reflecting this complexity) grows, no single company or group of companies can afford the entire cost and risk associated with the development of new energy sources.

At a time when both industry and government are cutting RD&D expenditures because of tight budgets, it becomes increasingly critical that both work together to ensure a technology base to provide needed energy sources at a cost that is affordable and in a time frame that will meet the growing needs of this nation. Only by communicating and working together can this be accomplished.

INCENTIVES

Some of the old tax credits targeted at producing energy are expiring, and industry is moving toward an environment with less federal assistance in the form of incentives for production of energy supplies. With these developments, it is time to look at the emerging need for tax incentives for RD&D. Tax incentives are required to encourage technological development, which is necessary in the future for economically viable gas supplies.

Both the gas and the electric industries are exploring an enhanced research and experimentation (R&E) tax credit provision to accomplish two goals. One is to remove the current disincentives for collaborative research contained in the R&E tax credit that expired last summer. The other is to look for ways to make the playing field more level between in-house research conducted by a company and collaborative research is conducted by third-party entities. At the time the expired R&E tax credit was written, collaborative research was not prevalent in industry. However, with shrinking research and development (R&D) dollars available within industry, it is becoming more and more common to see companies pool their resources to participate in collaborative research. This practice should be encouraged.

Revisiting the expired R&E tax credit is sound policy at a time when shrinking research dollars in both government and private industry are a reality. Collaborative research is more efficient in terms of both dollars and time spent. The disincentives in the expired R&E tax credit could be corrected by extending and modifying the credit to:

- Recognize contributions to 501(c)(3) collaborative research organizations as qualifying for the tax credit;
- Redefine "qualified research" to encompass the IRS definition of qualified research for a 501(c)(3) organization;
- Allow 100 percent (vs. 65 percent in the expired bill) of expenditures for collaborative research to qualify; and
- Provide a 20 percent nonincremental tax credit for company contributions to collaborative research activities conducted by 501(c)(3) organizations.

SUMMARY

U.S. producers have met increasing gas demand over the past decade with 50 percent fewer new gas wells than in the past. Despite low wellhead prices, drilling activity since the mid-1980s has been profitable. The cost to find, develop, and produce gas in the

United States has averaged about $1.50 per million British thermal units (MMBtu) since the mid-1980s, down almost two-thirds from its peak of $4.26 per MMBtu in 1982.

Major factors contnbuting to industry profitability since the mid-1980s are higher recovery per well, lower well and equipment costs, declining interest rates, and improved drilling success rates. Most of these improvements have been the direct result of technological advances.

RD&D is cntical to the future of the gas industry in a continuing era of low energy prices. Because of past RD&D, we are currently enjoying plentiful supplies of natural gas at low costs. To ensure the same stability for the future, RD&D must be continued both on a federal level and a private level. To discontinue or further drastically reduce gas RD&D would put future gas supply in jeopardy. It would "technologically bankrupt" the gas industry.

Tax credits for collaborative research are a sound national energy policy and should be reinstated by Congress. In the recently expired legislation, collaborative research was penalized by the existing definitions of what types of research qualify for the tax credit. Small changes to the definition and level of expenditures for collaborative research that qualify for the tax credit would significantly increase participation in collaborative research.

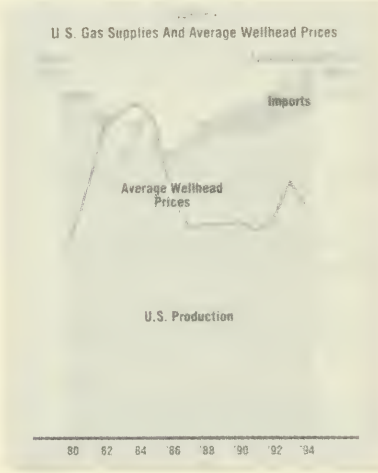
I thank the Subcommittee for its invitation to testify and will be happy to answer any questions and provide additional information.

Technologies and Improved Strategies Have Lowered Finding Costs and Opened New Exploration Opportunities

Introduction

Despite a decline in wellhead gas prices and reduced drilling levels since the mid-1980's, U.S. gas production has steadily increased, and total supplies have met increasing levels of demand. The ability of producers to meet increasing U.S. demand despite reduced drilling levels has resulted from both technological advances and industry practices and strategies that have increased efficiency, reduced costs, and expanded the recoverable resource. As a result, overall costs of finding and developing gas in the U.S. have declined significantly.

Exhibit 1 shows that U.S. gas supplies have increased 28 percent since 1986. While gas imports from Canada more than tripled during this period, U.S. gas production provided over 60 percent of the increase in U.S. gas supply. U.S. gas production increased despite the fact that gas prices are substantially below their peak levels of the early 1980s and the annual number of new gas wells drilled has averaged under half the peak levels of the early 1980s.

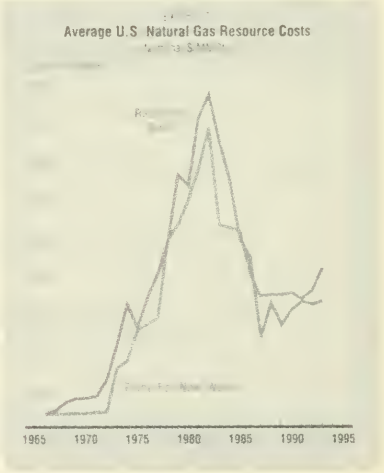


With the expectation of continued low wellhead gas prices, it is important to understand the factors that have reduced finding costs and increased well recoveries, and to evaluate whether gas supply can continue to grow with little or no increase in gas prices. **The key issue is whether the trend of improving technology that contributed significantly to the success of the last ten years can reasonably be expected to continue for the next ten to twenty years.**

Resource Costs For Natural Gas

The cost of finding and developing new gas reserves in the U.S. has declined greatly since the peak of industry activity in the early 1980s, allowing economic gas development and increasing production despite low prices.

Exhibit 2 shows average U.S. nonassociated gas resource costs for the years 1966 to 1993. The resource cost of natural gas is defined as the total cost of finding, developing and producing new gas including royalties, taxes, and a rate of return to the producer. Components of resource cost include exploration costs, drilling and completion costs, drilling success rates, recovery per successful well, operating costs, and rate of return. With the exception of rate of return, which is tied to the market cost of capital in each year, all of these components are affected by technology advances.



The chart shows that nonassociated gas resource costs peaked in 1982 at $4.26 per MMBtu (nominal dollars) and then declined through 1987. Since 1987, resource costs have ranged from $1.14 to $1.60 per MMBtu and have averaged about $1.50 per MMBtu. The total decline from the 1982 peak to the 1993 value of $1.60 was $2.66 per MMBtu.

Several factors have combined to lower resource costs. The total decline of $2.66 per MMBtu is the net of factors that reduced costs by $2.83 and factors that increased costs by $0.17. Fifty-nine percent of the $2.83 reduction was due to increased recovery per well. Other factors include reduced well and equipment costs (22 percent), lower interest rates (16 percent) and improved drilling success rates (3 percent). Reduced value for natural gas liquids was the primary factor that increased costs by $0.17.

Also shown on Exhibit 2 is the natural gas price that new wells would have been expected to get each year. Through 1982, the gas prices for new wells reflect the prices allowed by government regulation under the Natural Gas Act and Natural Gas Policy Act. Since 1982, gas prices increasingly have been influenced by market forces, which now are the sole factor. As a result, the new gas price since 1982 is the average gas price in that year.

Exhibit 2 shows that through the mid-1980s, resource costs were almost always higher than the gas prices new wells could obtain. Only since the mid-1980s have gas prices generally been higher than resource costs. This implies that through the mid-1980s, the profitability of new industry investment depended on a continued increase in gas prices. Since the mid-1980s, profitability does not appear to require further growth in gas prices.

Reserve Additions Per Well And Completion

Recovery per well is a good measure of industry's ability to efficiently discover and develop new reserves. Both recovery per well and recovery per completion have increased significantly in recent years, allowing industry to maintain an adequate reserve level with fewer new wells and at lower prices than in the early 1980s.

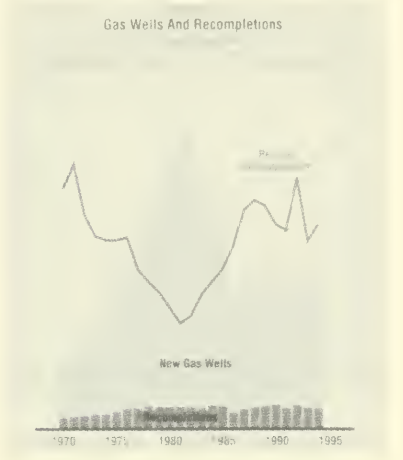
The usual method of evaluating recovery per well employs annual nonassociated reserve addition data compiled by the Energy Information Administration and annual new gas well counts compiled by the American Petroleum Institute. These data indicate that since the mid-1980s, recovery per well nationally has averaged about 1.5 billion cubic feet (Bcf) — about 90 percent above the average of the previous 10 years.

The almost doubling of recovery per well has been driven by increased recovery per completion and a growing share of recompletions in industry activity. Improved recovery per completion has been the primary factor, and has resulted from both improvements within regions and from movement by industry to more productive regions and depth intervals.

Recompletion Activity and Effect on Recovery Per Well

The focus of industry gas completion activity has changed significantly over the last decade. Through the mid-1980s, industry added new reserves and deliverability principally by drilling new wells. Only in the Gulf Coast onshore and offshore regions and the Arkoma Basin in the Mid-Continent region did recompletions (i.e., the second or later completions in a wellbore) play a significant role. Since the mid-1980s, the pressures of low prices have led industry to look more closely at potential gas reserves behind the pipe.

Exhibit 3 shows the historical trends in new gas wells, recompletions, and the percentage of recompletions since 1970. Recompletion counts are from the Dwight's completion level database. Total gas completions (new wells plus recompletions) peaked in 1981 at about 21,800 and then declined. Since the mid-1980s, they have ranged from 10,000 to 12,000 per year. Recompletions per year doubled from 1970 to 1980, and have been relatively constant since that time at about 1,600 per year.



The recompletion share of total gas completions has varied greatly. The recompletion share was high in the early 1970s, declined throughout the 1970s, reached a low point during the peak of industry activity, and increased throughout the 1980s. Recompletions increased from a low of 7 percent in 1981 to a high of 18 percent in 1992. In the Gulf Coast region, recompletions in recent years have accounted for more than 40 percent of total completions. This is indicative of the large volume of gas behind the pipe in this region.

Average gas recovery per recompletion has been increasing in recent years, as operators are finding ways to target the best intervals. This trend is a major factor in making recompletions attractive. In addition, recompletion activity is often the lowest cost option for adding new reserves, and this type of activity is expected to remain high with continuing low prices.

Analysis of recovery per completion values shows that about 10 percent of the recent increased recovery per well can be attributed to the increasing role of recompletions in adding reserves and deliverability. The remaining 90 percent can be attributed to improved recovery per completion.

Recovery Per Completion

Exhibit 4 shows recovery per completion trends for both new onshore gas wells and recompletions in non-Appalachian areas. In the late 1960s and early 1970s, recovery per completion ranged from 2.0 to 2.3 Bcf. This was followed by a decline through the 1970s to levels of 0.7 to 1.0 Bcf. From 1985 through 1991, new well non-Appalachian onshore com-

pletion recoveries increased from about 1.0 Bcf to over 1.5 Bcf, while recompletion recoveries increased from 0.7 to over 1.0 Bcf. Offshore gas completions show similar trends.

The increased recovery per well and per completion since the mid-1980s has been in large part a direct result of the introduction of new gas supply technologies. Examples include 3-D seismic, advanced logging and reservoir evaluation tools, and improved and lower cost computer hardware and software. These new capabilities have allowed operators to explore for new high productivity plays and to more effectively target high quality areas within existing fields.

The emergence of major gas plays with high well recoveries has also been important. Examples include coal seam gas development in the San Juan Basin, high productivity conventional reservoir plays such as the Norphlet trend in the Eastern Gulf of Mexico, and tight sands. In most cases, the discovery and/or economic development of these plays has been the result of relatively recent technology improvements, technology-related cost reductions, and improved fracture design stemming from a better understanding of the geology and production characteristics. Analysis of the improved recovery per well and recompletion indicates that about one-third of the recent improvement in reserve additions per gas well can be attributed to increased recovery per well in individual regions and depth intervals.

Activity by Location and Depth Interval

Industry practices and regional patterns of activity have also improved average well recovery. Gas completion activity has declined in lower well productivity areas such as the Appalachian Basin, more wells are being completed in deeper, higher recovery reservoirs, and significant increases in recompletion activity, especially in the Gulf Coast province, have resulted in higher recoveries as additional reserves are added to existing wellbores.

Since the early 1980s, the average depth of completed gas wells in the U.S. has increased significantly. Because deeper wells and offshore wells find much higher reserves per completion, the shift to such wells accounts for more than half of the overall national increase in recovery per well that has occurred since the mid-1980s.

The national trend of increased drilling depths has resulted from both deeper drilling within regions, and a shift toward drilling in regions with deeper reservoirs. From 1981 through 1994, the average drilling depth of U.S. onshore gas wells increased from 5,400 to 6,600 feet. During this time, the percentage of gas wells drilled to the 0-5,000 foot depth interval declined from 60 percent to 38 percent of all gas wells, while drilling below 5,000 feet increased from 40 percent to 62 percent. Most of the increase in the deeper drilling percentage occurred in the 5-10,000 foot interval.

Exhibit 5 shows recovery per completion by depth interval for new (non-Appalachian) onshore gas well completions and offshore gas completions from 1986 through 1991. Onshore completion recoveries increase from 0.81 Bcf per completion above 5,000 feet to 6.58 Bcf per completion below 15,000 feet. Offshore completions during the period averaged 8.84 Bcf.

EXHIBIT 5
Average Recovery Per New Gas Well Completion
1986-1991

	Onshore Interval (ft)				
	0-5000	5-10,000	10-15,000	+15,000	Offshore
Recovery Per Completion (Bcf)	0.81	1.33	3.20	6.58	8.84
Recovery Ratio (0-5,000=1)	1.0	1.6	3.9	8.1	10.9

Dwights DOGR database, non-Appalachian areas.

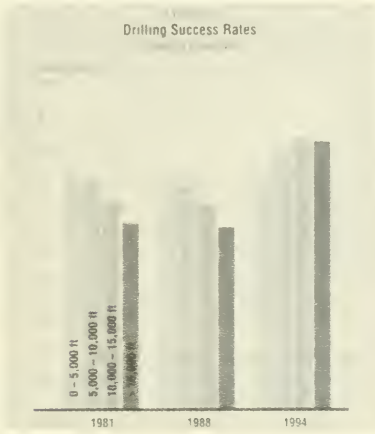
When converted to a multiple of the recovery of the first onshore depth interval, the values for successively deeper intervals are 1.6, 3.9, and 8.1. The multiple for offshore completions is 10.9. Thus, the reserves added by drilling 1,000 new gas wells in onshore sediments shallower than 5,000 feet could be provided by 610 wells in the 5-10,000 foot interval, 250 wells in the 10-15,000 foot interval, or only 120 wells below 15,000 feet. If the new wells were only in the offshore, fewer than 100 new wells would be needed.

These data are indicative of recent and continuing industry success in adding reserves in deeper onshore intervals and offshore areas. They can also be viewed as a measure of the excellent potential for profitable future deep reserve additions. With a continuation of the national trend toward deeper gas exploration and development, average recovery per well should continue to increase.

Drilling Success Rates

Historically, onshore Lower-48 success rates have generally declined with depth. Exhibit 6 shows onshore Lower-48 total drilling (exploratory plus development) success rates by 5,000 foot interval for selected years. The chart shows that through the late 1980s, success rates generally declined with

depth. Since 1988, this trend has changed. Success rates now show a general upward trend with increasing depth. In 1994, onshore success rates increased from 70 percent above 5,000 feet to 77 percent between 5,000 and 10,000 feet, and exceeded 80 percent below 10,000 feet.



While this change had only a modest impact on overall onshore success rates, improving them from 69 to 75 percent in 1994, the sharp increase in success rates with depth since 1988 has reduced the risk of deeper drilling in onshore areas and has been a major contributing factor in the shift of activity to deeper targets. Reported drilling activity for the first two quarters of 1995 suggests that the shift to deeper drilling is continuing, particularly below 10,000 feet.

Increased success rates for deeper wells also have had a substantial effect on the share of total drilling expenditures for dry holes. In 1988, 25 percent of onshore drilling expenditures were for dry holes, while in 1994, the dry hole fraction is estimated to have declined to 18 percent or less.

New technology has played a major role in the improved success rates. Technology effects include the use of 3-D and advanced 2-D seismic, improved geological and engineering data acquisition and interpretation, and improved drilling and completion technologies. Technology effects also include more widespread and effective use of existing technologies, such as the increased use of seismic data before drilling new wells.

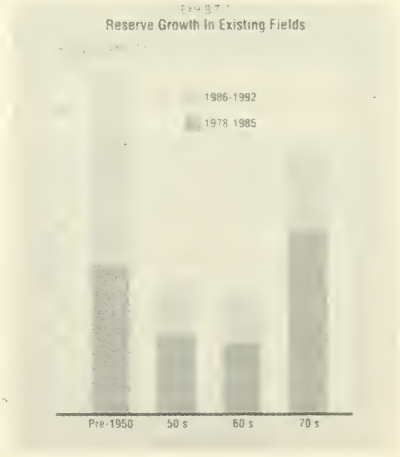
The acquisition of 3-D seismic data for both exploration and development has increased dramatically since 1988, and explains why success rates have increased for deep drilling in recent years. By November 1994, 64 out of 80 land crews and 34 out of 37 offshore crews were shooting 3-D seismic, while onshore 3-D activity was minimal as recently as 1988. Exploratory success rates have increased substantially over the past few years in the Gulf Coast and Gulf of Mexico provinces, the most active exploratory regions of the U.S. and the primary areas where 3-D seismic is being used.

In some areas, directional drilling capabilities are being increasingly used as a method of improving success rates by allowing the testing of multiple, laterally separated exploration targets in one well. Using this approach, the probability of an economic discovery is much higher than with a vertical well evaluating one target and the recovery per well is generally much higher. In the first half of 1995, more than one-fourth of U.S. wells were directionally drilled or horizontal, more than double the share in 1993.

Reserve Growth In Existing Fields

Reserve additions in known fields have played an important role in the improved rate of reserve additions since the mid-1980s. These reserve additions are far in excess of what reserve growth estimates through the mid-1980s would have indicated. Current resource estimates for remaining reserve growth potential are much higher, and indicate that the recent scale of reserve additions will continue. The current GRI estimate of Lower-48 reserve growth potential is 244 Tcf, and the recent USGS estimate indicates that total Lower-48 growth potential in discovered fields exceeds 300 Tcf.

Exhibit 7 shows the historical growth in proven ultimate recovery of existing fields by decade of field discovery for fields discovered through the 1970s. The exhibit shows that gas reserves grew substantially in all fields despite their age. Between 1978 and 1992, reserve additions to fields discovered through the 1970s totaled 218 Tcf — much larger than the estimates of their potential in the late 1970s. Most surprising is the large reserve growth in fields discovered before 1950. Since 1978, these fields have grown 87 Tcf, and almost 60 percent of this amount was added since 1986.



Much of the recent reserve growth has been in the Gulf Coast and Gulf of Mexico regions, where the geology is characterized by multiple stacked reservoirs, productive intervals up to several thousand feet thick, complex faulting, and

reservoir heterogeneities. This complex geology results in a wide range of potential intra-field exploration opportunities to discover deeper pools, bypassed reservoirs, or untapped compartments.

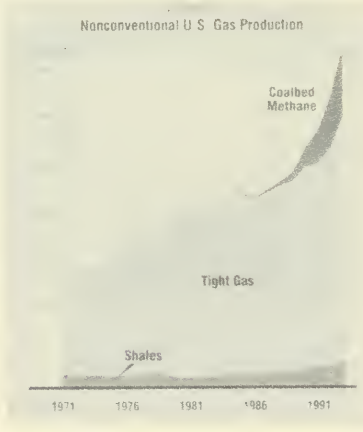
Exploration for deeper, more subtle targets has been made possible through recent advances in seismic technologies. New geological concepts and improved engineering data and models are allowing operators to target untapped compartments in productive intervals. New completion techniques, including horizontal drilling and improved fracture design, have resulted in improved recovery per completion. Exploratory and development opportunities exist in essentially every large field, and exploration for deep reservoirs and bypassed compartments using new technologies is still in its early stages.

Higher reserve growth potential in current fields also implies greater potential in undiscovered fields. Because estimates of conventional undiscovered potential are generally based upon analysis of the size distribution of fields discovered by increments of past exploratory drilling, increased recovery from historical fields means that new discoveries should be expected to be larger as well.

Nonconventional Gas

Advanced completion and stimulation technologies and reduced costs have allowed increased economic development of tight reservoirs, coalbed methane, and shale. Such nonconventional reservoirs now contribute significantly to Lower-48 gas production and proven reserves, and large-scale undeveloped resources are present.

Exhibit 8 documents the increase in nonconventional gas production from 1971 through 1993. During this time, tight gas production increased from 1,091 Bcf to 2,626 Bcf per year, coalbed methane production increased from nearly zero to 732 Bcf per year, and Devonian/Antrim Shale gas production increased from 119 Bcf to 289 Bcf per year. Total nonconventional production in the U.S. increased from 1,240 Bcf to 3,647 Bcf. The fraction of U.S. dry gas production represented by nonconventional gas has risen from 5.7 percent in 1971 to 20.0 percent in 1993.



Non-conventional gas production has increased in recent years despite low gas prices and the phasing out of tax incentives. Almost all of the coalbed methane development and production increases have occurred since the mid-1980s. The primary reason for this is that prior to the 1980s, production technology and understanding of the coalbed methane resource were inadequate to encourage significant economic development. While nonconventional drilling tax incentives were a significant factor in the increased drilling levels of the early 1990s in areas such as the San Juan Basin, the underlying trend is one of improved economics resulting from higher well recoveries and reduced costs.

Recent advances in fracture design for tight sands have reduced costs and improved well performance. For example, the recent fracture design advances developed by GRI have reduced fracture costs 10 to 50 percent and improved well performance 40 to 300 percent. As these and other technology advances become standard practices, nonconventional gas production should continue to increase.

Emerging Lower-48 Frontier Areas

The Lower-48 contains extensive frontier areas, deep sediments, and nonconventional deposits with excellent gas potential. In fact, over half of Lower-48 sediments can still be considered frontier. Industry's ability to economically explore and develop these resources has been greatly enhanced by recent technology advances.

Exhibit 9 shows the Lower-48 regions in the GRI Hydrocarbon Model that have frontier sediments remaining to be explored. Extensive undeveloped resources of tight gas, coalbed methane, and Devonian Shale are present in the non-frontier portions of these regions, but these less conventional gas resources are considered a technology frontier, in that economic development with continued low gas prices will require continued advances in drilling, stimulation, and completion technology.

Deep frontiers can be found in almost all major Lower-48 gas provinces. Many producing basins have sedimentary rock sections of 20-30,000 feet in thickness or more. However, with the exception of areas such as the Anadarko Basin and South Louisiana, exploration and development below 10,000 feet has been minimal. In the East Texas/Arkla Basins, the Gulf Coast of Texas, and Rocky Mountain areas, frontier drilling depths generally begin at about 10,000 feet, while in the Anadarko Basin, South Louisiana, and the shallow water Gulf of Mexico, large quantities of unexplored sediments are present below 15,000 feet. The map shows that largely unexplored deep sediments are present across almost the entire Gulf Coast region.

In recent years, the Gulf of Mexico has been the site of most frontier exploration. "Flex Trend" exploration in water depths ranging from 200 to 1,000 meters or more has been very successful, with over 100 total discoveries documented by the Energy Information Administration, of which possibly 50 or more will be economic to develop. Technology advances in deep water drilling and production facilities have been critical to this effort, and have opened up an

EXHIBIT 9
Major Known Exploration And Technology Frontiers Of The Lower-48

entire province with excellent future potential that could not have been economically developed a decade ago. The current maximum water depth of production in the Gulf is 2,860 feet at Auger field, and within the next few years, production is anticipated at the Ram-Powell (3,218 feet) and Mensa (5,400 feet) discoveries.

The other major frontier in the Gulf is the Subsalt play, which extends across a huge area of the shelf and slope regions off of Texas and Louisiana. Seismic acquisition and processing technologies have opened this play, allowing imaging of previously undetectable structures beneath salt layers up to several thousand feet thick.

Implications

U.S. producers have met increasing gas demand over the past decade with far fewer new gas wells than in the past. Despite low wellhead prices, drilling activity since the mid-1980's has been profitable. The cost to find, develop, and produce gas in the U.S. has averaged about $1.50 per MMBtu since the mid-1980s, down almost two-thirds from its peak of $4.26 per MMBtu in 1982.

Major factors contributing to industry profitability since the mid-1980s are higher recovery per well, lower well and equipment costs, declining interest rates, and improved drilling success rates. Most of these improvements have been the result of technology advances. The 1996 Edition of the GRI Baseline Projection expects these advances to continue, thus maintaining industry profitability with limited growth in real oil and gas prices. In the 1996 projection, real oil prices remain constant. While real gas acquisition prices are projected to increase somewhat during the 1990s, after the year 2000, they do not increase.

In the 1996 projection, U.S. gas supply increases from 21.1 Tcf in 1994 to 23.0 Tcf in the year 2000. By the year 2015, the end of the 1996 projection period, U.S. gas supply is approaching 29 Tcf. About three-fourths of the increased U.S. gas supply is from Lower-48 gas production.

Gas supply growth in the 1996 projection depends on continuing the technology advances which industry has achieved during the past decade. Average recovery per gas well continues to increase for most of the projection period, consistent with the trend observed since the mid-1980s. Average recovery exceeds 2 Bcf for most of the projection, largely because of the continued shift of industry activity to more productive offshore or deeper onshore sediments. However, the 1996 projection does not reflect recent improvements in success rates with depth, which have played a major role in the shift of drilling activity to the offshore and deeper onshore sediments.

The 1996 projection expects that gas production from nonconventional sources will continue to grow, particularly after the 1990s. This growth reflects the effects of technology advances, many of which have been funded by GRI, that improve recovery per well from nonconventional gas sources and reduce the costs of their development. By the year 2000, nonconventional production is 3.9 Tcf; by 2015, it is 8.4 Tcf. In 2015, more than one-third of Lower-48 gas production is nonconventional, compared to one-fifth in 1993.

The 1996 projection describes an optimistic outlook for U.S. gas supply. The improved recovery per well expected in the 1996 projection depends critically on the development of new technology that improves recovery from existing plays and allows industry to move into more productive deeper onshore sediments and deeper water offshore sediments. Industry activity is moving into more productive areas at a more rapid rate than the 1996 projection expects, indicating that resource prospects in these areas will probably exceed GRI's expectations. The critical challenge to industry is to maintain the rate of technology advance near the rate that it has achieved in the last decade.

Questions or comments should be directed to Thomas J. Woods at GRI's Baseline/Gas Resource Analytic Center (202/662-8989).

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Statement by
Denise A. Bode
President
The Independent Petroleum Association of America
Washington, D.C.
before the
Subcommittee on Energy and Mineral Resources
Committee on Resources
U.S. House of Representatives

March 21, 1996

Mr. Chairman And Members Of The Subcommittee:

I am Denise Bode, president of the Independent Petroleum Association of America (IPAA). I am pleased to offer testimony on behalf of America's independent oil and natural gas producers. We appreciate your leadership in scheduling this hearing on America's oil and natural gas resource base and federal initiatives for domestic exploration and production. These hearings before the Subcommittee on Energy and Mineral Resources on the domestic oil and natural gas industry and the potential role of public lands and the Outer Continental Shelf are essential if we are to educate the public on the importance of national energy security. Our nation has important choices to make on energy policy, which require us to look realistically at our vulnerabilities and needs.

I am here with you today to talk about a **new way of thinking**. I want to share with you information about a major IPAA case study of the United States natural gas and oil resource base, the role independents will play in accessing and developing that vast resource base, and the role of the U.S. government.

The **old way of thinking** about oil and natural gas production in the United States was based on elephant fields that gave rise to giant, global corporations. Now, in the twilight of the Twentieth Century, those companies are shifting investments overseas, still looking for those giant fields, chasing that **old way of thinking**.

They've left behind a huge resource base of oil and natural gas. Despite what's been said, America is not running out of oil and natural gas. New technological innovations have revolutionized exploration, drilling, and production processes expanding our knowledge of America's vast potential for domestic oil and gas supplies. There is an abundant resource base in the United States, but to unlock that potential requires our nation to re-think the old ways, to seize change and the opportunity it brings.

A **new way of thinking** is emerging from lean, aggressive independent oil and natural gas producers that are responsive enough to meet the economic challenges of finding and developing the literally thousands of fields that await discovery and improved resource recovery. America's independents have the technological know-how to efficiently find and produce natural gas and oil. And many large companies, in recognition of these efficiencies, are reorganizing or forming companies that call themselves and behave like independents.

THE RESOURCE BASE

According to geologists and petroleum engineers, America has abundant oil and gas resources. Recent resource estimates (including proved reserves) indicate total supplies of 204 billion barrels of oil and 1,295 trillion cubic feet (TCF) of natural gas--a resource/production ratio of 62 years for oil and 68 years for natural gas. Nearly half of the resource lies in new exploratory development, and half in existing fields. America's remaining oil and gas resources are greater than our cumulative production from 1857 to the present. However, these resources will only be developed if America's exploration and production companies are allowed to accomplish the task.

These American resources--the reserves of the future--will by and large be found and developed in small increments. It is the nature of our geology in the United States that we have vast amounts of reserves held in these small increments or "jack rabbit" fields as we call them in the business. Although certain trends (particularly the deep, unexplored portions of several major basins) contain potential for the discovery of giant gas fields, new fields will be generally less than 100 billion cubic feet (BCF) of gas. Often they are as small as 10 BCF of gas. Development of reserves in existing fields or trends likewise will be in small increments, with additions of 1 to 2 BCF of gas for each well drilled.

In November 1993 IPAA published a resource base study entitled, The Promise of Oil and Gas in America. This study was the product of our Potential Resources Task Force which was formed to interpret the results of the experts' resource studies (such as the 1992 National Petroleum Council study and a 1992 DOE study), and to corroborate them with the actual experiences of independent producers in the U.S. The members of this committee were chosen to include nationally recognized resource analysts as well as a broad spectrum of independent producers and earth scientists. The study analyzed natural gas and oil plays/trends with significant discoveries or developments back to 1986. Our survey resulted in 56 cases of significant discoveries or developments in 16 states, providing just a sample of significant events, not necessarily the largest reserve additions during the period. This sample does form a good cross-section of how productive exploration and production activity is undertaken. Some important themes are evident:

-- New reservoirs were often found with new technology--mostly improved seismic and 3D seismic data, and better drilling and completion technology.

-- However, the most important development is improved geological concepts. In many cases, old tests "condemned" a large area or a trend; improved vision, based on better

gas-finding ideas was necessary to successfully find and develop reserves. Pay zones with anomalous responses may have been bypassed, but can now be recognized. Wells without reservoir rock may represent local anomalies rather than regional truths.

-- Drilling technology was also critical to the success of many projects. This includes proper fracturing techniques, mud systems, economical drilling, and better logging and evaluation methods.

-- Reservoir characterization was critical to most infill drilling projects. A solid understanding of the hydrocarbon reservoir is replacing "blind" spacing reduction in improving field recoveries.

THE CASE STUDIES

Independent producers have gained new insights and skills that are enabling them to successfully find and develop natural gas and oil in areas long thought to be nonproductive. A few case histories of recent developments taken from the survey responses and other information serve to highlight the continuing potential of American's gas plays. These important additions to the U.S. reserves were undertaken in today's price regimes, and use today's geological concepts and geophysical and engineering technology.

Gulf of Mexico Subsalt

The first successful subsalt well was drilled in 1990. Since then 15 subsalt wildcats have been drilled by 10 different operators. Five have made discoveries. It has been estimated that as much as 2 billion barrels of oil equivalent lies beneath the salt sheets that occur under 40% to 60% of the Gulf of Mexico. The use of new techniques such as 3D depth migration and super computers have made it possible to get clear images of the geologic structures underneath the salt sheets. It is still difficult and expensive to drill subsalt wells. Well depths are typically 15,000 to 20,000 feet and cost between $8 million and $20 million to drill. Currently there are 2,475 leases with subsalt potential. 1,711 are still in their primary term with the other 764 held by production from formations above the salt.

Austin Chalk

The Austin Chalk trend that runs through Texas and into Louisiana is a formation that has been unlocked due to improvements in horizontal drilling technology. Wells are drilled vertically to the proper depth and then "kicked-off" and a "lateral" is drilled an additional 2,000 to 5,000 feet horizontally. This technique allows producers to link several small pockets that would be uneconomic to develop conventionally. Newer techniques allow companies to drill multiple laterals from a single vertical well.

North Dakota Lodge Pole

Before 1993, the lodgepole formation had only produced 3,200 barrels of oil in 35 years. Since then several fields with an estimated 50+ million barrels of recoverable oil have been found in a 10 mile radius of Dickinson, North Dakota. Conoco along with independent producers such as Armstrong Operating Company and True Oil have led the development of this find. While development has been confined to Stark County it is widely believed that these mounds extend over a wide area. Many companies are acquiring leases and conducting

the 3D seismic surveys that are necessary to find these elusive mounds. An additional benefit of these surveys is that they are finding additional reserves in other formations that are economic to produce but can not justify the $30,000 a square mile cost of 3D seismic.

Cotton Valley Reefs

The East Texas Basin has been producing oil and natural gas for over 70 years. Natural gas has been produced from two Cotton Valley reefs since the early 1980's. However, full development of this trend was hampered by the depths a small size of the formations as well as the complex geology. The use of 3D seismic technology has enabled companies to pinpoint these structures. Many of these structures hold as much as 50 Bcf of natural gas. The Cotton Valley reefs are another example where new technology has unlocked additional reserves in a mature producing province.

THE FRONTIER WILDCARDS

In addition, the report highlights the fact that the United States has an immense hydrocarbon frontier consisting of:

-- basins which have not produced gas or oil yet;
-- areas of producing basins which have not been adequately tested;
-- deeper parts of producing basins, or downdip of known production; and
-- unrecognized or "unconventional" reservoirs.

Overall, some fifty basins or portions of basins in 38 states were judged by the IPAA Task Force to have possibly significant potential for future reserve addition. This is not meant to be exhaustive nor predictive, but does indicate the scope of potential activity. In addition, one should take into consideration the "stumble factor." It has been said that more oil or gas was found on wrong geology than right geology. Major new plays have often resulted from chance encounters on the way to a dry deep objective.

Our resource base report shows that we can meet our country's need for oil and gas for many years to come, through intelligent and efficient exploration and development. But these needs can only be met through drilling. To convert the resource into reserves and production on the time scale needed by the American economy will require a significant increase of industry effort. It will require the ability to form sufficient capital to mobilize the rigs and create these jobs. And it will required a partnership by government to make the resource base accessible.

THE ROLE OF THE INDEPENDENT

Independents are ideally suited to find and develop the resource base in the United States. Most of the large multinational companies, with higher overhead requirements, need the giant fields and large projects to break even. This has been one of the main reasons for their shift to overseas exploration. As you can see, there has been a fundamental change in the domestic industry. It used to be that independents were the primary "wildcatters" in the business drilling over 85 percent of the exploratory wells. Although they have always been the

principle natural gas producers, producing over 65 percent of the natural gas consumed in the United States and 38 percent of the oil produced (50 percent in the lower 48 states), they used to make the deals, find the natural gas and oil and then sell the proven property to a major company to develop using the capital to invest in the next new wildcat. Today, not only are the independents finding the resource but they are also the main purchasers of the proven properties for the first time in our history. This trend will continue with more properties (some estimate in the neighborhood of $10 to $15 billion worth) which have been largely unexploited in recent years by the majors being purchased by independents who are skilled at exploiting and enhancing reserves in the ground at the lowest cost.

To further underscore the fundamental change in the domestic industry is the role now being played by the independent in production offshore the United States. I don't need to remind you that over 28 percent of our supply of natural gas is produced offshore. Independents have won 57 percent of the primary term leases and 70 percent of the producing leases issued from 1990 through 1994. In 1995 independents drilled 59 percent of all wells in the Gulf of Mexico. Even in this more difficult and expensive environment the independent is the key domestic player. Independents are even venturing into deep water, which was once considered an arena that was exclusive to the majors.

Independent producers have smaller staffs, lower overhead costs, and can act aggressively and move quickly to capitalize on new opportunities and adjust to meet these new challenges. The successful independent has developed his niche, becoming the world's leading expert in a certain geological trend or technology. They use these advantages to reduce finding costs and increase success rates. Our industry provides high-tech jobs which are generally better paying than other industries on the whole. And when I talk about our industry being a high tech industry, I'm not kidding, the domestic industry uses some of the most sophisticated software and hardware in the United States.

The Twenty-First Century holds great promise for a renaissance in the entrepreneurial spirit that founded America's natural gas and oil industry near Titusville, Pennsylvania in 1859. To fulfill that promise, the private sector, the government and the American public must change the way they look at the industry and recognize the expanding and, indeed, dominate role that independent producers have particularly in the oil and gas industry's present and future in this country.

THE ROLE OF THE AMERICAN GOVERNMENT

Clearly, the United States has significant oil and natural gas reserve potential. However, these domestic resources will not be found and produced under policies that put huge areas of public lands off limits to exploration and production and which shoulder the domestic industry with unnecessary and anti-competitive costs. If this potential is to be realized by the domestic petroleum industry the federal and state governments need to adopt a unified philosophy which supports instead of opposes the development of our domestic resources. More than a decade of low prices, rising imports and increasing regulatory costs have decimated the ranks of independent producers and discouraged investments in U.S. resources.

Since the early 1980s over 500,000 American jobs have been lost, 95,000 since 1991. There are several important actions that Congress can take to assist domestic independent oil and natural gas producers.

-- Remove tax penalties for exploration, technology and improved oil and gas recovery. This presentation has focused on the fact that technology is what is allowing us to keep our edge, yet the use of this technology such as 3D Seismic cannot be expensed. As a result of this technology, producers are reporting between a 50% and 85% improvement in finding rates. But it is expensive, sometimes as much as 70% of the cost of drilling a well. Domestic exploration and production can be spurred through the immediate expensing of geological and geophysical costs, and the economic life of existing production can be improved through changes to percentage depletion.

-- Reform the regulatory development process to incorporate risk assessment, sound scientific principles, cost benefit analysis, and flexibility. Increasingly stringent environmental compliance requirements are severely limiting industry's ability to meet the nation's demands for oil and gas. An example is EPA's proposed expansion of its Toxic Release Inventory program to cover oil and gas exploration and production. This proposal would inflict burdensome costs with no environmental benefits and only give the public an inaccurate and misleading report on an industry that poses a low risk of public exposure from its operations. More cost-effective methods for adequately protecting the environment while permitting exploration and production are required. The exploration and production industry spends over $1.6 billion annually in environmental compliance costs. Pending regulations could nearly triple those costs to over $5.5 billion by 2000. We encourage Congress to pass legislation that mandates the use of sound science and cost benefit analysis in the development of all federal regulations.

-- Reform of the federal royalty program. Payment of royalties is a cost of doing business. The royalty collection process should be predictable and fair to both industry and the government. It is not. A coalition representing the entire exploration and production industry support the concepts of the Federal Oil and Gas Royalty Simplification and Fairness Act. The current federal royalty program has not kept pace with the rapidly evolving natural gas market. In today's market it is not unusual for royalties payments to become due before complete sales information is available to the producer. The current system encourages overpayment in order to avoid routinely assessed penalties, and puts the producer in the position of giving the government an interest free loan. For producers with substantial federal lands production, the overpayment can amount to millions of dollars. Rep. Ken Calvert's Royalty Fairness bill, which is scheduled for a March 28 mark up before the full committee, promotes a cost-effective and efficient program with a real statute of limitations and interest on royalty overpayments not timely refunded. The bill is a win-win for both industry and the federal government.

-- Amend the Oil Pollution Act of 1990 (OPA90). Earlier I mentioned the great strides that independent producers are making in the development of our nation's offshore resources. While most of the Outer Continental Shelf remains under Presidential and Congressional

moratoria, many independents may be forced to leave the federal offshore altogether if OPA90 is not amended. Last year, as part of the Coast Guard authorization bill, the House and Senate passed amendments clarifying the definition of an offshore facility, establishing the financial responsibility certification requirement for facilities at $35 million, and limiting direct action lawsuits against guarantors. Congressional staff are currently preparing for consideration of the differing House and Senate amendments before a conference committee.

-- Allow independent producers, who provide more that 60 percent of the domestic natural gas supply, a limited anti-trust exemption to encourage the formation of natural gas marketing cooperatives. The Federal Energy Regulatory Commission's Order No. 636 was intended to bring more competition to gas markets by giving producers more options to sell their gas and consumers more options to purchase supplies. But independent gas producers are either too small or their reserves too regionally dispersed to compete with consolidated firms that aggregate supplies and offer an array of services to end users and local distribution companies. H.R. 2342, the Natural Gas Competitiveness Act, would grant a limited exemption and allow producers to join together and aggregate their gas production, thus enabling them to deal directly with consumers and market larger packages of supply.

CONCLUSION

Estimates conclude that 70 percent of our tremendous domestic oil and resource will only become available if favorable new government policies are instituted, the newest and most efficient technologies are applied widely, and operating capital returns to the industry. Coordinated action by industry and the federal government is necessary to secure the future development of energy supplies. Government in particular must realize that we can meet our country's needs for natural gas for many years to come, and stem the flow of oil imports for many years to come. This can be accomplished through intelligent policies that grant access to our country's vast reserves and lift the many regulatory obstacles that hamstring the domestic oil and gas industry.

That concludes my testimony. Thank you, Mr. Chairman.

U.S. Public Interest Research Group

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TESTIMONY OF ANNA AURILIO, STAFF SCIENTIST

U.S. PUBLIC INTEREST RESEARCH GROUP

before the

HOUSE SUBCOMMITTEE ON ENERGY AND MINERALS

March 21, 1996

U.S. PIRG 218 D Street, SE Washington, DC 20003 [illegible]6-9707

I am Anna Aurilio, Staff Scientist for the U.S. Public Interest Research Group (U.S. PIRG). We are pleased to testify on Federal energy policy, in particular, Federa policy on domestic oil and gas production.

U.S. PIRG is the national lobbying office of the state Public Interest Research Groups. PIRGs are non-profit, non-partisan and work on environmental, consumer and good government issues in more than 30 states.

Because energy use and production is the largest source of pollution, and because inefficient energy use costs consumers money, U.S. PIRG and PIRGs around the country have been working to shift energy priorities from polluting sources of energy such as fossil and nuclear energy towards energy efficiency and clean, renewable energy sources such as solar, wind and geothermal.

Americans overwhelmingly favor a shift towards clean efficient energy sources. According to a public opinion poll conducted in December 1995, by Republican pollster Vince Breglio, 55% of those polled believed that renewable energy and energy efficiency programs should receive top priority for funding in DOE's research budget.

The state PIRGs which comprise our board have been working to develop and implement policies which prevent pollution, and they have been working to protect our most sensitive offshore areas from oil and gas drilling, particularly in Florida and California. We have been working nationally to prevent oil and gas exploration and drilling in the Arctic National Wildlife Refuge. According to the December 1995 poll, 62% of those polled opposed drilling in the Arctic National Wildlife Refuge.

We are very concerned about our reliance on imported oil, and the economic drain caused by this reliance and our current wasteful energy practices. We believe that our greatest source of domestic oil savings lies in dramatically increasing the fuel economy of cars and light trucks. The December, 1995 poll showed that 94% of those polled strongly or somewhat favored raising fuel efficiency for cars and light trucks.

We also believe that the domestic oil and gas industry should look to increasing the efficiency of its own operations, both in terms of energy use and oil waste, rather than continuing to fight to drill in environmentally-sensitive areas. Finally, a sound energy policy is one which will move us towards a clean, affordable energy future. Subsidies to mature, polluting industries such as the oil and gas industry should be phased out.

1. Increased Reliance on Fossil Fuels has Grave Public Health and Environmental Consequences

Our increasing reliance on oil has grave public health and environmental consequences. Oil production and refining are major sources of pollution, oil burning, especially in motor vehicles is a leading cause of air pollution and

greenhouse gas emissions.

All aspects of oil production have major environmental consequences. Oil drilling disrupts the environment, and often leads to the release of oil and toxic and radioactive materials. Oil refining is a major source of chemical releases reported through the Toxics Release Inventory. According to Friends of the Earth, the oil industry loses approximately 280 million barrels of oil equivalent a year through leaks, spills and inefficiency alone.

Oil use threatens our health. Nearly 100 million Americans live in areas with unhealthy air. Automobiles and power plants are the major culprits in generating the harmful gases that comprise urban smog and acid rain. In many urban areas, motor vehicles are the major source of smog-forming chemicals.

Increased reliance on fossil fuels threatens the global environment. The International Panel on Climate Change continues to warn about the perils of doing nothing to curb the emissions of greenhouse gases. The threat of increased storm severity, and therefore higher claims, is real enough to the insurance industry, which has already been buffeted by record-breaking storm damages in the last several years. Finally, public health specialists are warning of a potential increase in tropical infectious diseases linked to climate change.

2. Our Current Wasteful Energy Practices have led to increased reliance on Imported Oil and a Drain on our Economy

A recent report by Public Citizen and the American Council for an Energy-Efficient Economy estimated that failure to curb our appetite for oil cost us jobs and economic prosperity. They estimate that national employment in 1992 would have increased by about 475,000 jobs had the U.S. taken steps to increase energy efficiency. Wages and salaries would have increased by nearly $12 billion because of higher productivity levels. Less wasted energy means less wasted money that can be spent on other products.

3. Energy Efficiency and Renewable Energy Sources will Save Oil and Boost our Economy

Energy efficiency measures will help prevent further energy-related public health and environmental problems and save money. According to various sources, investments in energy efficiency and renewable energy resources over the next 20 years can create a net increase of more than 1,000,000 jobs while decreasing total energy use per unit of economic output by 30 percent.

By far the most important single step to save oil and curb global warming is to increase fuel economy of cars and light trucks. The U.S. Should "Drill under Detroit" to curb our dependence on foreign oil and save money. A significant increase in fuel economy would save more oil than we import from the entire Persian Gulf. Increasing

fuel economy by sixty percent would also: slash emissions of smog-forming chemicals by 500,000 tons per year, and would save the average household in the U.S. approximately $580 per year in fuel costs.

We already reap the benefits of the fuel economy increases which occurred between 1973 and 1987, largely because of implementation of Corporate Average Fuel Economy (CAFE) standards for cars and light trucks. During those years, average fuel economy increased by nearly 90 percent, and we save over 3 million barrels of oil per day compared to what fuel consumption would have been without the standards. Even at the current low gasoline prices, consumer cost saving amount to $50 billion per year. Unfortunately, since 1988, new fuel economy has actually declined to 25 miles per gallon (MPG). This decline is due in part to a growing market share for gas-guzzling light trucks.

It's time to put the advances in automotive technology towards saving money and the environment. Publicly available statistics of 1993 new car and truck models show that the "best in class" cars and light truck achieve over 20% better fuel economy. A study released by the PIRGs, the Sierra Club and the Center for Auto Safety showed how existing technologies could be used to improve the fuel economy of the Ford Taurus, one of the best-selling cars in America, by 54%. Others have an even more optimistic outlook on current automotive technology. Amory Lovins, Director of the Rocky Mountain Institute, estimates cars achieving 150 mpg are possible using existing technology and with continued improvements, fuel economies of 600 mpg would be achievable.

Other energy efficiency measures can help us save oil as well. Alternative transportation measures such as mass transit, carpooling, biking and walking all save oil. The Department of Energy's (DOE) low income weatherization program which helps low income citizens become more financially independent through energy efficiency measures saves the equivalent of 5 million barrels of oil per year.

The petroleum industry itself should save money and oil by improving energy efficiency and oil recovery in existing wells. According to Friends of the Earth, these improvements could lead to an estimated 800,000 barrel per day replacement of oil imports, creating jobs and reducing the trade deficit.

In addition to increasing the efficiency with which we use existing energy sources, renewable energy sources are becoming increasingly cost-competitive. Even the most profitable oil company in the world, Royal Dutch/Shell predicts that renewable energy sources may make up one third of the supply of new electricity within the next three decades even if electricity from fossil fuels continues to decline in cost. The December 1995 poll showed that 90% of those polled strongly or somewhat favored developing renewable energy alternatives to oil.

4. Federal Subsidies for the Oil Industry should be phased out.

The oil industry already reaped an estimated $5.5 - $8.8 billion in subsidies in 1989, according to the Alliance to Save Energy. The petroleum industries is a mature industry which should be weaned from the federal dole, rather than continuing to receive taxpayer handouts such as the new deepwater royalty "holiday". According to the December, 1995 poll, only 7.2% of those polled believed that oil, gasoline and coal should receive federal tax incentives for research and development.

DOE's petroleum research and development program should also be phased out. Industry is already conducting much of this work on its own. The Congressional Budget Office's "Reducing the Deficit: Spending and Revenue Options", 1995 points out that "In the area of fossil energy R&D... commercial firms already spend a great deal of money to develop new technologies. The major new technologies for enhanced oil recovery, for example, have come from private industry, not DOE." According to the December, 1995 poll, only 8.6% believed that research and development for oil, gasoline and coal should receive the highest priority for DOE funding.

CONCLUSION

Americans around the country want a clean environment and a sound economy. Energy efficiency and renewable energy sources are the most promising paths towards a clean, affordable energy future. If Congress is serious about saving oil and protecting the environment, it will support increased fuel economy standards for cars and light trucks, not rollbacks of current law as embodied in H.R. 2020. If Congress wants to spur new technologies which will generate jobs and help us move toward a clean, affordable energy future, it will increase support for energy efficiency and renewable energy programs, and not implement deep funding cuts such as those contained in the FY96 Appropriations bills.

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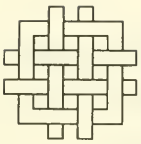
SUMMARY OF COMMENTS

ENERGY PRIORITIES SHOULD SHIFT TOWARDS ENERGY EFFICIENCY AND RENEWABLE ENERGY SOURCES.

NO DRILLING IN ENVIRONMENTALLY-SENSITIVE AREAS.

IMPROVEMENTS IN FUEL ECONOMY FOR CARS AND LIGHT TRUCKS REPRESENT THE GREATEST SINGLE STEP TOWARDS SAVING OIL AND CURBING GLOBAL CLIMATE CHANGE.

SUBSIDIES FOR THE FOSSIL FUELS INDUSTRIES SHOULD BE PHASED OUT.



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Before the Subcommittee on Energy and Mineral Resources
Committee on Resources
U.S. House of Representatives
Washington, D.C. 20515

March 21, 1986

My name is James J. MacKenzie and I am a Senior Associate at the World Resources Institute, a non-profit policy-research center focusing on issues of sustainable development and the environment. Thank you, Mr. Chairman, for the invitation to testify before this committee on the subject of the Nation's oil and gas resource base.

I have just completed a peer-reviewed study of U.S. and global crude oil resources and plausible scenarios for annual production. This paper touches upon fundamental issues of interest to this committee and I have included copies of the study with my testimony.

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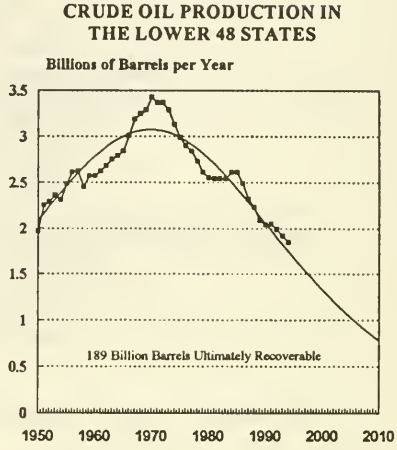
The approach that I took was modeled after that of M. King Hubbert, the late American geophysicist who 40 years ago predicted the future of U.S. oil production with amazing accuracy. The underlying assumption of this approach is that -- given sufficient geological exploratory work -- petroleum geologists and engineers can make a reasonable estimate of ultimately recoverable crude oil in a given region. Hubbert reasoned that production in any given region will someday peak and begin its resource-driven decline, generally following a bell-shaped curve. Fitting estimates for U.S. ultimate oil resources to simple curves he concluded that U.S. production would peak somewhere between 1965 and the year 1971. As it turns out, he was right: lower 48 production peaked in 1970 and has been declining since. See the Figure.



I have done a similar analysis for production from known Alaskan fields and this is also included in my report. I found that, for the north slope, about 14 billion barrels will ultimately be produced, of which 12 billion (86 percent of the total) had been produced by the end of 1995. (The Alaskan

analysis does not include potential deposits in the Arctic National Wildlife Refuge (ANWR).)

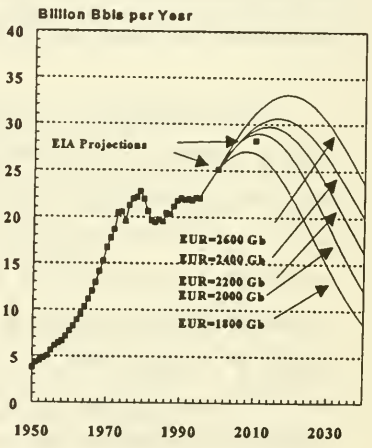
The United States is the most explored real estate in the world. There are about 900,000 producing oil wells in the world and two thirds of them are in the United States. Yet, there are some who argue that if only financial incentives were greater, large amounts of new oil would be found. Perhaps, but the evidence is not supportive. From the early 1970s to the mid 1980s, when world oil prices were very high -- $30 to $58 per barrel, in 1993 dollars -- exploration in the United States hit new records; yet proved reserves and production both continued their decline. (Incidentally, the large Prudhoe Bay field in Alaska was found in 1968, long before the exploration frenzy brought on by the price rise following the 1973 Middle East war.)

The conclusion is inescapable that the United States is nearly through its oil-producing era and there is not a whole lot more oil to be found. There could be a few billion barrels of oil in the Arctic National Wildlife Refuge (ANWR) -- and I certainly agree that this is not an insignificant amount of oil -- but even three billion barrels (EIA's estimate of a decade ago) would be largely gone in a decade. According to EIA's base case for ANWR, production could rise over five years to a peak of 790 thousand barrels per day and then begin its decline. Total oil demand at that time is projected to be about 20 million barrels

per day, so ANWR might briefly account for a maximum of about 4 percent of supply around the timeframe of 2010 to 2015. Oil imports, at that time, are expected to account for about 57 percent of supply. Clearly three billion barrels of oil do not really change the long-term outlook for U.S. oil use or dependency on imports.

I have repeated this kind of analysis for conventional global crude oil production and these results are also presented in my paper. Briefly, I found a near consensus that global ultimately recoverable oil lies between 1800 and 2200 billion barrels. Of this, some 765 billion barrels have already been produced. Doing the same kind of analysis as for the United States, one concludes that **world crude oil production will probably peak sometime between 2007 and 2019.** The accompanying figure shows scenarios for world oil production for various values of Estimated Ultimately Recoverable (EUR) oil. EUR is most likely in the range of 1800-2200 billion barrels. See the paper for further details.

GLOBAL OIL PRODUCTION FOR EUR = 1800, 2000, 2200, 2400, 2600 Gb



There are other analysts, such as Petroconsultants of Geneva, the oil industry's most authoritative source on resources, who are more pessimistic than I. They conclude that global production could peak as early as the year 2000. I include their arguments in my paper and also address counter-arguments to the basic approach that I have taken. Such counter-arguments include:

- Global reserves will last over 40 years at present rates of consumption. **Not so, a reserves/production ratio of 40 years cannot be interpreted to mean production could stay constant for forty years. Production declines as reserves are depleted. It takes continuous finding of new reserves to maintain production.**

- Higher oil prices will lead to vast new oil discoveries. **The record shows this has not happened. During the decade from the mid 1970s to the mid 1980s, when prices were high, world exploration expanded greatly, yet no new giant fields were found.**

- China and Russia have huge reserves waiting to be discovered. **Perhaps but this possibility is already included within the very large estimates of ultimately recoverable oil allocated for these two countries.**

From this analysis one can only conclude that new energy sources will have to be introduced globally to meet the demand now met by oil, especially in the transportation sector. The

pressures will come not only to cope with resource constraints, but to help reduce air pollution and greenhouse gas emissions, especially CO_2, as well. The imminent move from oil to replacement energy sources will occur over a just a few decades, and determined efforts to make the transition as painless as possible should begin now. Perhaps most critical is the need to make energy prices -- especially those of fossil fuels -- reflect the full social costs of their production and use. In practice, this can be most efficiently achieved through pollution-, security-, and carbon (global warming) taxes. New taxes such as these could be offset by reducing taxes on income or savings or by reducing social-security or health-care taxes.

As excess global oil production capacity gradually disappears over the coming decade, oil prices can be expected to rise. When and by how much will depend on such unknowns as the growth in global oil demand, the timing and speed of production declines, and the availability of suitable substitutes. Early planning -- our best hope in mitigating potential impacts -- should entail an integrated program of price reforms, reducing demand for oil, and expanding the supplies of alternative sources of energy, preferably non-carbon sources because of the need and international obligation to begin mitigating global climate change.

Thank you, Mr. Chairman. This completes my testimony.

THE PROMISE OF OIL AND GAS IN AMERICA

Actions for Increased Production of U.S. Natural Gas and Oil

Final Report of IPAA Potential Resources Task Force
November 1993

Areas with some potential for future discoveries
Areas producing oil and natural gas
(will yield more if drilling is substantially increased)
Areas where major new fields have been discovered since 1986
Frontier areas, unexplored but with significant potential
for new, major discoveries
IPAA 5/93

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Acknowledgements

The IPAA Potential Resources Task Force thanks all those who contributed to the survey, both members of the IPAA and geologists with the State surveys. Special thanks go to Richard Nehring of NRG Associates for the play information; the IPAA Staff for manifold services; and to Venus Oil company, for sponsoring the compilation of the report and graphics.

IPAA owes a special debt of gratitude to Dr. Thomas E. Ewing, who has served as Chairman of the Task Force during 1992-1993. He has a wide range of experience in and understanding of the geology of many major North American oil and gas provinces. Dr. Ewing is noted for his tenure as a research associate under Dr. William F. Fisher at the Bureau of Economic Geology at the University of Texas at Austin, where he was an author of the Atlas of Major Texas Oil Reservoirs. He is also a principal author of the recently published Tectonic map of Texas. He is President of Frontera Exploration Services, Inc. and an exploration consultant to Venus Oil Company in San Antonio, Texas.

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November 5, 1993

Dear Reader:

The Independent Petroleum Association of America (IPAA) is very proud to have been the sponsor of this important report, *The Promise of Oil and Gas in America: Actions for Increased Production of U.S. Natural Gas and Oil*. This in-depth study confirms that there are abundant petroleum resources remaining in the United States -- more than 62 years for oil and 68 years for natural gas at current reserve/production ratios.

This is good news for independents who will be at the forefront of finding and developing them. The domestic petroleum industry has undergone a fundamental change that has transformed all aspects of doing business, including its relationship with government and investors. One very important factor is the new "technology revolution" which is reducing costs, improving finding rates, and making independents even more efficient in exploration and production. Independents are uniquely able to find and develop the potential natural gas and oil resources documented in this report.

Hopefully, these results can encourage the return of investment from outside sources to our industry and can be used by independents to identify new trends to drill and develop significant reserves. The key is to form a partnership between government and industry that recognizes the new business environment and makes the adjustments needed to keep the U.S. natural gas and oil industry working.

Although there have been several recent studies estimating the large amount of petroleum resources remaining in America, no one analysis has attempted to put all the pieces together -- including both natural gas and oil -- for the industry, policymakers, and the public. And so, the myth has continued to persist that the U.S. is running out of domestic oil and natural gas. This report looks at the previous resource estimates and analyzes the potential from the point of view of the successful explorationist who will be involved in future efforts to find and develop these resources.

The IPAA Potential Resources Task Force was formed in May, 1992 to provide the evidence that would once and for all dispel the myth that there is no significant oil and gas left to be found in the U.S. As part of that effort, prospective geological trends were identified that may yield vast resources for America. IPAA is very grateful to Dr. Thomas E. Ewing, who has served as Chairman of the IPAA Task Force with great dedication and expertise. We also want to thank all of the independents, geologists and experts who served on the Task Force representing the many geographic regions and geological provinces which contain our vast undeveloped hydrocarbon resources.

Sincerely,

George A. Alcorn
Alcorn Exploration, Inc.
IPAA Chairman of the Board

Sincerely,

Gene Ames, Jr.
Venus Oil Company
Immediate Past IPAA Chairman

THE PROMISE OF OIL AND GAS IN AMERICA

Actions for Increased Production of U.S. Natural Gas and Oil

Final Report of IPAA Potential Resources Task Force
November, 1993

Introduction and Executive Summary

The old way of thinking about oil and natural gas production in the United States was based on giant fields that gave rise to large, global corporations. Now, in the twilight of the Twentieth Century, those behemoth companies are shifting investments overseas, still looking for those giant fields, chasing the old way of thinking.

Yet, America is not running out of oil and natural gas. Recent technological innovations that have revolutionized exploration, drilling and production processes also have greatly expanded our knowledge of America's vast potential for domestic supplies of natural gas and oil. There is an abundant natural gas and oil resource base in the United States, but to unlock that potential requires our nation to re-think the old ways, to seize change and the opportunity it brings

A new way of thinking is emerging from lean, aggressive independent natural gas and oil companies that are "right-sized" to meet the economic challenges of finding and developing the literally thousands of oil and natural gas fields that await discovery and improved resource recovery. America's abundant energy resources are geologically suited for the technologically-smart companies that can efficiently find and produce natural gas and oil from a large number of fields of all sizes. And, who knows, there may yet be a giant or two hiding somewhere beneath the surface.

The Twenty-First Century holds great promise for a renaissance in the entrepreneurial spirit that founded America's natural gas and oil industry near Titusville, Pennsylvania, in 1859 To fulfill that promise, the U.S. government and the American public must change the way they look at the industry and recognize the expanding and, indeed, dominant role that independent producers play in the industry's present and future in this country.

After nearly a decade of low prices, rising imports and increasing regulatory costs that decimated the ranks of independent producers and discouraged investments in U.S. resources, independent producers today are scoring impressive successes using new geological concepts, innovative drilling techniques and computerized seismic technology. In the process, these entrepreneurs are creating jobs and new economic wealth—and discovering new oil and natural gas resources—in some 40 major production areas in 20 states.

Moreover, independent producers have gained new insights and skills that are enabling them to successfully find and develop natural gas and oil in areas long thought to be non-productive. For example, in 1960 a wildcat well in the Expanded Yegua Trend of the Texas Gulf Coast near Beaumont produced a few thousand barrels of oil from a thin poor-quality sandstone. This well "condemned" the formation and part of the trend for decades. Then in 1989, using new geological concepts, an independent producer made a case for development. Modern, high-quality seismic data was acquired through the partly urban area. A discovery well found several hundred feet of high-quality sandstone and produced at over 10 million cubic feet (MMCF) of natural gas and 1,000 barrels of condensate per day. Now 12 new wells help to provide the natural gas that America needs.

A similar new-concept exploratory success is in north-central Oklahoma, where geological identification and analysis of an anomaly—an ancient meteorite impact crater—was followed by three-dimensional (3D) seismic interpretation. Following successful drilling of highly fractured Arbuckle and basement rocks, total reserves developed by independents may reach 30 million barrels of oil.

According to geologists and petroleum engineers, America has abundant resources. *The most recent resource estimates (including proved reserves) indicate total supplies of 204 billion barrels of oil and 1,295 trillion cubic feet (TCF) of natural gas—a resource/production ratio of 62 years for oil and 68 years for natural gas.*

However, 70 percent of this tremendous resource will only become available if favorable new government policies are instituted, the newest and most efficient technologies are applied widely, and operating capital returns to the industry. About half of these future resources are from existing fields or areas, and half will be from new discoveries.

In order to convert America's natural gas and oil resources into delivered products, assure the nation's end-users of a reliable supply, and contribute trillions of dollars to the economy, at least a doubling of industry effort is required. Coordinated action by industry, government, and the investment community is necessary to secure the future development of energy supplies. Government in particular must encourage the needed investment in America's natural gas and oil.

Studies over the last five years have converged on estimates which show convincingly that America's natural gas and oil resources are abundant. *In fact, as much natural gas and oil will be found and produced in the future as has ever been produced from 1857 to the present—if only America's exploration and production (E&P) companies are allowed to accomplish this task.* Unfortunately, the myth of the exhaustion of America's resources has pervaded much of the country's energy debate.

The Independent Petroleum Association of America (IPAA), as the national trade association representing independent oil and natural gas producers, formed its Potential Resources Task Force in May 1992 to interpret the results of the experts' resource studies, and to corroborate them with the actual experiences of independent producers in the United States The members of the committee were chosen to include nationally recognized resource analysts as well as a broad spectrum of independent producers and earth scientists.

We hope that this report with its maps and charts will help to explain the promise of America's natural gas and oil resources, and the important role that independents will play in the nation's energy future.

U.S. Natural Gas and Oil Resources

Many studies of America's oil and natural gas resource base have been conducted over the last ten to twenty years. In the last several years, the experts have moved toward agreement that this resource base is large, and that advances in technology are essential to finding and adding gas and oil resources—as essential as higher prices, a stable price environment, and improved access and regulatory climate.

Natural gas and oil are inextricably linked at many levels. At the simplest level, gas is nearly always produced with oil, and oil (light oil, known as "condensate") is very often produced with natural gas. In many trends of natural gas E&P, known as gas-condensate plays, half or more of the revenue is derived from this condensate. On another level, exploration for natural gas will often find oil, and vice versa. On still another level, the prices of oil and gas are loosely linked, because residual fuel oil and natural gas are interchangeable for many industrial users.

Thus, even though the natural gas and oil resource studies have been conducted separately, the resources themselves are not separate. Independents explore for and produce both natural gas and oil simultaneously, and the future of America's production industry depends on both.

■ *Natural Gas*

The most recent and most comprehensive study of natural gas resources is the work of the National Petroleum Council (NPC), completed in 1992 Their findings are summarized in Table 1, and illustrated in Figure 1. The NPC first estimated the total resource base on a "technically recoverable" basis, assuming access to the resource and foreseeable technology advancement, but no given price level. By the NPC estimate, the total remaining resource base is 1295 TCF, distributed between new discoveries of gas in conventional fields, gas in tight sands, reserve growth in existing fields through better geologic understanding and increased drilling, proved reserves, and other gas resource types (coalbed methane, shale gas, etc.). This should be compared with the 19 TCF/year which the U.S. uses at present, the American resource/consumption ratio is 68 years.

TABLE 1.
NATURAL GAS RESOURCE BASE FOR THE LOWER 48 STATES

Proved Reserves:	160	TCF
Reserve Growth:	203	
New Field Discovery:	413	
Tight Gas Sands:	349	
Coalbed Methane:	98	
Shales:	57	
Other:	15	
TOTAL RESOURCES	1295	TCF

Source: National Petroleum Council, 1992. This is the technically recoverable resource base as of January 1, 1991, assuming that current access moratoria expire as scheduled and incorporating technology advancement through 2010. Resource base at $3.50/MMBTU and advanced technology is estimated at 825 TCF.

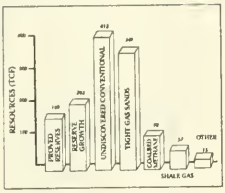
The NPC also estimated the recoverable resource for specific price levels, in real terms, and estimated the effect of technology. The resource base ranges from 400 TCF at today's prices and technology, to 825 TCF at a higher but realistic price and foreseeable technology. Figure 2 shows the relative influence of price and technology. As expected, the higher that price rises, the more gas can be produced. However, technological advances are equally as effective as price increases in increasing the resource base. In the NPC scenario, going from "current" to "advanced" technology yields the same addition to our resources as a price increase of $0.50-$0.80 per million BTU (MMBTU). Note: One MMBTU is approximately equal to one thousand cubicfeet (MCF)

A word on the technology scenarios: "Current technology" implies no change from the way the industry does business in 1990. "Advanced technology" means that the advanced gas-finding and developing techniques we have today are widely applied throughout the industry; and that technologies now in the research shops are moved into common practice in the industry by 2010. No "science fiction" assumptions are involved.

The NPC concluded that existing usage can be maintained through 2010 with prices at or below $2.50/MMBTU (with advanced technology). Anticipated future growth can also be supplied, with somewhat higher pricing levels. The very large Canadian gas resource (the conventional part of which alone has been estimated at 232 TCF), also will contribute substantially to meeting the growth in demand.

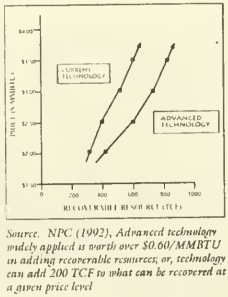
Of course, even "advanced technology" is a moving target. As our knowledge of gas deposits and recovery technologies grows, the resource base figures will expand. In fact, that is just what has happened over the last decade (Figure 3). As late as the mid-1980s, gas from tight sands and coal beds was considered "unconventional" and little if any was included in resource assessments. Today it forms a major part of the resource base, and a major part of the economies of several states.

FIGURE 1.
NATURAL GAS RESOURCE BASE BY CATEGORY



Source: NPC (1992), Technically recoverable case for Lower 48 states

FIGURE 2.
EFFECT OF TECHNOLOGY AND PRICE ON NATURAL GAS RESOURCES



Source: NPC (1992), Advanced technology widely applied is worth over $0.60/MMBTU in adding recoverable resources; or, technology can add 200 TCF to what can be recovered at a given price level

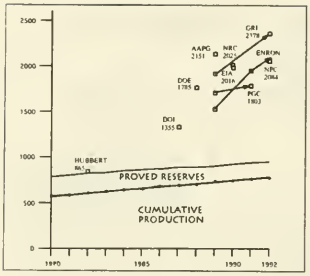


FIGURE 3.
COMPARISON OF VARIOUS ESTIMATES OF TOTAL NATURAL GAS ENDOWMENT
Note: The increasing figures for total endowment (production, reserves and resources) with time reflect advancing technology

Where does this resource base occur? Although this cannot be predicted in detail, the distribution of 1991 gas reserves is probably a good guide to the future. Figure 4 shows that most of the gas reserves lie in a broad swath from the Louisiana-Texas Gulf Coast (onshore and offshore) northwest to Wyoming. Other significant areas are Alabama and Mississippi, California; and the Appalachian Basin and Michigan Basin (from Kentucky through Pennsylvania and Michigan). Alaska has a significant natural gas reserve base; much more could be added if the transportation problems can be solved. It should be remembered that all of these reserve/resource estimations assume continued access to prospective and producing lands, and no further restrictions due to environmental regulation.

■ *Oil*

No study comparable in scope and authority to the NPC natural gas report has been undertaken for America's oil resource base. However, there has been a trend toward a rough consensus of experts, similar to the history of gas resource studies. The estimates of U.S petroleum resources have fluctuated widely over the years (Figure 5), but have greatly increased with time due to technological advances. These estimates can be divided into three periods:

-Before 1955, resources were estimated to be only slightly above the level of proved reserves. Thus, America was always just about to run out of oil. The reasons for hydrocarbon accumulations were poorly known, and it was impossible to predict future sources of supply

-From 1955 to 1980, two types of resource estimates competed. The higher figures, as high as 600 billion barrels of total endowment, were generated by analysis of volumes of prospective sedimentary rock. The lower figures, hovering at under 200 billion barrels of total endowment, resulted from Hubbert's analysis of production history as a bell-shaped curve. Note that we have already produced more oil than Hubbert's original estimate (1958) of total endowment!

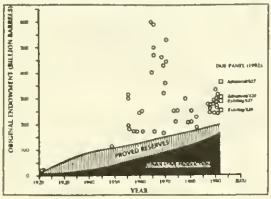
-After 1980, resource estimates have converged in a broad band, higher than the Hubbert-like models. These estimates have generally increased with time, reflecting improved concepts and technologies.

The most recent estimation of the oil resource base, completed in October 1992, was commissioned by the Department of Energy (DOE) and chaired by Dr. W.L. Fisher. This study brought together a wide range of experts; each shared their data and estimates of oil resources, which were then discussed and averaged into "best-estimate" figures (Table 2, Figure 6). The estimates were conducted for a specific series of prices ($20 and $27 per barrel), and for technology scenarios of "existing technology" and "advanced technology" similar to those used by the NPC for natural gas.

The results of the DOE study indicate that we have up to 204 billion barrels of domestic resource (obtainable at $27 per barrel using advanced technology). This recoverable resource is evenly split between discovery of new oil fields and reserve growth within existing fields. Even onshore in the Lower 48 states, the DOE process estimates that 24 to 48 billion barrels remain to be discovered in new fields, while 24 to 70 billion barrels (over proved reserves) can be obtained from existing fields by geologic and engineering studies followed by drilling. Compared with annual U.S. oil production of 3.31 billion barrels, the resource/production ratio is 62 years.The DOE

FIGURE 4.
NATURAL GAS
RESERVES BY STATE FOR 1991
Source: DOE (1992), Future discoveries and reserve growth will mostly occur in the areas with highest production and reserves. Notice that figures for Texas and Louisiana include major offshore production

Figure 5
COMPARISON OF DOE 1992 RESOURCE ESTIMATES AND OTHER STUDIES



Source: DOE (1992), Estimates from 1920 to 1955 were based on production; from 1955 to 1980, based on either statistical analysis (low numbers) or volumetric analysis of sedimentary basins (high numbers); after 1975, estimates converged. The envelope surrounding 1980s estimates shows an increase with time, reflecting advances in technology.

figures show directly the relative influence of price and technology on oil resource estimates (Figure 7). As with natural gas, technology use has an impact similar to that of price. In the case of oil, technology advance is equivalent to a price increase of about $7.00/barrel.

Where will oil be found in the future? It is impossible to say for sure, but one key is the distribution of today's oil reserves (Figure 8). The greatest reserves are in the traditional oil patch (Gulf of Mexico-Louisiana-Texas-Oklahoma-Kansas, with New Mexico and Mississippi); the Northeast (Illinois-Ohio and surrounding states); California; Wyoming; and Alaska.

Although this report focuses on the undeveloped resource base, we must not overlook the fact that the developed, producing oil and gas resources are a precious resource which must be preserved. It is a fact that existing oil production in the U.S. from the older, major oil fields is declining at an accelerating rate.

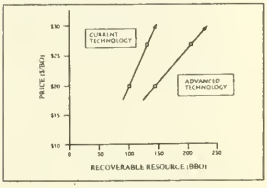
Stripper oil wells, which produce less than 15 barrels per day, can constitute an important future oil resource if federal policies are instituted which will extend their economic life. In addition, the old stripper well bores provide continued access to oil reservoirs so that advanced technologies can be applied. Few of the old reservoirs would be economic to redrill if the old wells were plugged. However, the high cost of compliance with environmental regulation could cause premature loss of a substantial amount of oil production from marginal and stripper oil wells unless allowances are made and compensating fiscal policies are enacted. The hour is late and the situation is urgent if we are to save these essential stripper and marginal oil wells.

TABLE 2.
OIL RESOURCE BASE FOR THE UNITED STATES

Proved Reserves 25 Billion Barrels(BBO)	
Reserve Growth:	
Lower 48 onshore	70 BBO
Lower 48 offshore	6 BBO
Alaska	13 BBO
Subtotal....	89 BBO
New Field Discovery:	
Lower 48 onshore	48 BBO
Lower 48 offshore	17 BBO
Alaska	25 BBO
Subtotal.....	90 BBO
TOTAL RESOURCES:	**204 BBO**

Source: DOE 1992. These figures represent the average of Panel members' estimates of oil resources recoverable at real prices of $27/barrel, assuming advanced technology.

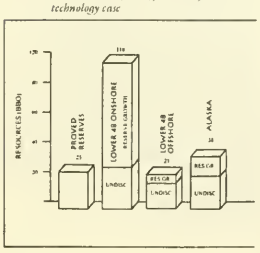
FIGURE 7.
EFFECT OF TECHNOLOGY AND PRICE ON U.S. OIL RESOURCES

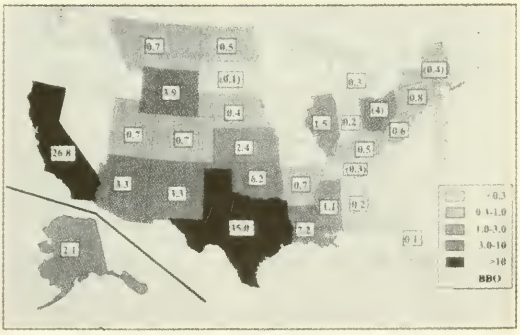


Source: NPC (1992), Advanced technology widely applied is the equivalent of a $7-$10/barrel of oil price increase; or, technology adds 50-80 billion barrels to the nation's oil resources.

FIGURE 8. UNRECOVERED MOBILE OIL BY STATE AS OF 1987
Source: DOE, Future discoveries and reserve growth will mostly occur in the areas with the highest production and reserves. Significant offshore reserves in California, Texas and Louisiana are included with state totals.

FIGURE 6.
U.S. OIL RESOURCES BASE BY CATEGORY
Source: DOE (1992), $27/Bbl, Advanced technology case





The Role of the Independent

The DOE and NPC studies show that America has abundant natural gas and substantial oil resources which will serve the country's needs. For both oil and gas, nearly half of the resource lies in new exploratory development, and half in existing fields.

But these resources—the reserves of the future—will by and large be found and developed in small increments. Although certain trends (particularly the deep, unexplored portions of several major basins) contain potential for the discovery of giant gas fields, new fields will be generally less than 10 million barrels of oil or 100 billion cubic feet (BCF) of gas. Often they are as small as 300,000 barrels of oil and 10 BCF of gas. Development of reserves in existing fields or trends likewise will be in small increments, with additions of a few hundred thousand barrels of oil or 1 to 2 BCF of gas for each well drilled.

Independents are ideally situated to find and develop these resources. Major companies, with higher overhead requirements, need the giant fields and large projects to break even. This has been one of the main reasons for their shift to overseas exploration. Independents are smaller and more flexible. If supplied with the proper technology and sufficient capital, they can economically find and develop the smaller increments of gas and oil resources.

Any measure of the efficiency of the industry showed a marked increase during the 1980s. Dividing the rotary rig count by reserves added in a year gives one simple measure (Figure 9); reserves added per foot drilled yields a similar picture (Figure 10). Finding costs have been declining steadily through the late 1980s as well.

Much of this increase in apparent efficiency is due to the low efficiency of earlier drilling. Simply put, in the panic-driven boom of the 1970s and early 1980s, there was too much money chasing too few good ideas, hence many risky or faulty projects were undertaken. Since 1986, good ideas have had to chase money, and only the soundest and least risky projects were undertaken. Nehring (1989) provides a readable analysis of this phenomenon. However, examination of efficiency and finding rates back to 1950 shows that there has been an absolute increase in efficiency and finding rates since 1985, even compared to the "pre-boom" 1960-1973 averages.

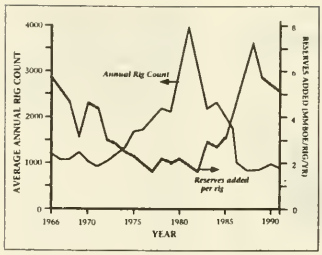


FIGURE 9.
ROTARY RIG COUNT AND RESERVE ADDITIONS

Source: University of Texas, Bureau of Economic Geology (Data for Lower 48 states).

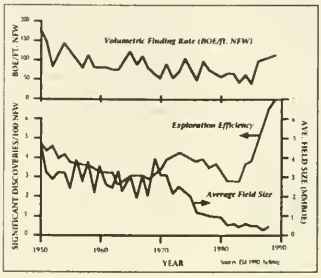


FIGURE 10.
BASIC EXPLORATION TRENDS

Source: University of Texas, Bureau of Economic Geology (Data for Lower 48 states).

This long-term increase in industry efficiency is principally due to:

—the widespread application of technology, especially ever-improving geophysical imaging by seismic reflection leading to fewer, better exploratory wells; and

—better understanding of reservoir makeup and behavior resulting in fewer, more strategically placed development wells.

Significant discoveries have been made across the country since 1986 (Table 3). Data collected by R. Nehring and extended for this study show that 40 plays (producing or exploratory geologic trends) have had significant discoveries or development (over 25 million barrels of oil equivalent, or MMBOE) under the present price and regulatory regime from 1986 to 1992. Half of the plays lie in the Gulf Coast Basin, both onshore and offshore; this area has accounted for over half of new reserves added. The largest plays by current estimate, are:

—Alaska North Slope; with Kuvlum, over 1500 MMBOE

—Cook Inlet Alaska; Sunfish, possibly 700 MMBOE

—San Juan Basin, NM; coalbed methane, some 830 MMBOE

—Mobile Bay, AL; Norphlet gas, some 500 MMBOE

—Pleistocene "Flexure Trend", offshore TX-LA, some 1000 MMBOE

—Pleistocene "Mississippi Fan Trend", offshore LA, 500 MMBOE

In addition, some of the other plays may be over 500 MMBOE, but the relevant figures are not yet available.

If the industry added these significant resources during a time of low and unstable prices (reflected in rig counts under 1000) and a government attitude of indifference, bordering on hostility, what could be done under a positive program of moderate growth?

IPAA Survey of Independents

To provide another avenue of understanding the present state of the industry, the IPAA Task Force surveyed the membership of the Association. The members were asked to contribute case histories of significant discoveries or developments in their area. In addition, state geological surveys were contacted for information on their states' gas and oil activity, and the Task Force analyzed published accounts.

This survey resulted in 56 cases of significant discoveries or developments in 16 states, as summarized in Table 5 at the end of this report. This is just a sampling of significant events, not necessarily the largest reserve additions, and must not be taken as encyclopedic.

The responses do, however, form a good cross-section of how productive E&P activity is undertaken (with some bias towards the exploration side). Some important themes are evident.

—New reservoirs were often found with new technology — mostly improved seismic and 3D seismic data, and better drilling and completion technology.

—However, the most important development is improved geological concepts. In many cases, old tests "condemned" a large area or a trend; improved vision, based on better oil-finding ideas was necessary to successfully find and develop reserves. Pay zones with anomalous responses may have been bypassed, but can now be recognized. Wells without reservoir rock may represent local anomalies rather than regional truths.

—Drilling technology was also critical to the success of many projects. This includes proper fracturing techniques, mud systems, economical drilling, and better logging and evaluation methods.

—Reservoir characterization was critical to most infill drilling projects. A solid understanding of the hydrocarbon reservoir is replacing "blind" spacing reduction in improving field recoveries.

—Major hinderances to development in urban areas, besides high costs and low prices, include difficulties with log evaluation, and wetlands/environmental regulations.

TABLE 3.
NATURAL GAS AND OIL PLAYS/TRENDS WITH SIGNIFICANT DISCOVERIES OR DEVELOPMENTS AFTER 1986

Plays from Nehring (NRG Associates, 1992) in which he defined plays with over 25 MMBOE found in one or more new field or new pool discoveries from 1986 to 1990. The IPAA Task Force added trends outside of Nehring's data base, plays which are primarily development in character, and plays which have had significant development since 1990 but did not appear on his list. Estimated known recoverable reserves in MMBOE for new discoveries are shown where given.

State:	Play	Production	MMBOE
Pacific:			
AK	Barrow Arch (Ellsmerian)	O, G	500+
CA	Mid-Valley (Cretaceous)	G	
AK	Cook Inlet (Tertiary)	O, G	
Rocky Mountain:			
ND	Mission Canyon Shorelines	O, G	
WY	Northeast Powder River (Minnelusa)	O	50
WY	Wamsutter Arch (Cretaceous)	G	
NM, CO	San Juan Basin (Fruitland, Menefee Coal)	G	830
Mid-Continent:			
TX	Deep Delaware Basin (Lo.Paleozoic)	G	
OK	Arkoma Basin (Arbuckle)	G	200
OK, KS, TX	Hugoton Embayment (Morrow Delt. Sand)	G, L	45
OK	Ouachita Thrust (Atoka Sandstone)	G	125
TX	Upper Pennsylvanian Slope Sandstone	L, G	60
TX	Wolfcamp Shelf-Edge Talus	O	
TX, NM	Delaware Group	O, G	50
Eastern:			
MI	Central Michigan (Prairie du Chien)	G, L	130
OH	Rose Run (Ordovician)	G	
MI	North Michigan (Salina - Niagaran)	O, G	30
MI	N. Michigan Antrim (Devonian Shale)	G	
WV, KY	Appalachian Basin (Devonian Shale)	G	
WV, PA	Appalachian Basin (Coal)	G	
Gulf Coast:			
AL, MS	Black Warrior (Upper Pottsville Coal)	G	300
AL	Mobile Bay (Norphlet)	G	500
MS, LA	Intermediate Tuscaloosa	O,G	40
AL	Southwest Alabama (Miocene)	G	50
TX, LA	Sabine Uplift (Jurassic Sandstone)	G	
TX, LA	Sabine Uplift (Cretaceous Sandstone)	G, O	30
TX	Rio Grande Valley (Lobo)	G	30
TX	South Texas Deep Wilcox + Wilcox Fault	G, L	135
TX	Central Coast Downdip Yegua	G, L	175
LA, TX	Hackberry Embayment (Frio)	G, L	75
TX	San Marcos Arch (Lo.Miocene)	G	35
TX OCS	Corsair Trend (Mid.Miocene)	G	45
TX OCS	Middle Miocene	G, L	250
LA, OCS	Middle Miocene	G, L	120
LA, OCS	Upper Miocene	G, L, O	125
LA OCS	Pliocene Shelf	G	150
LA OCS	Pliocene Slope	G, O	150
LA, TX, OCS	Pleistocene Shelf	G	100
LA, TX, OCS	Pleistocene Slope	G, O	1000
LA, OCS	Mississippi Fan (Plio-Pleistocene)	G, O	500

KEY: O = OIL G= NATURAL GAS L = NATURAL GAS LIQUIDS

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Case Studies: Technology Put to Work

A few case histories of recent, significant developments, taken from the survey responses and other information, serve to highlight the continuing potential of America's gas and oil plays. These important additions to the U.S. hydrocarbon reserves were undertaken in today's price regimes, and use today's geological concepts and geophysical and engineering technology.

At **Dickinson Field** in the Williston Basin of North Dakota, Conoco discovered deeper pay in 1993 below an older producing field. The well was the first production from the Lodgepole limestone formation in the North Dakota part of the Williston Basin. Reserves for the one well of 2.8 MMBO and 1.4 BCF gas can be calculated. Other significant deeper-pool discoveries beneath old producing trends include the **Rose Run Trend** in Ohio and **RCR Field** in East Texas.

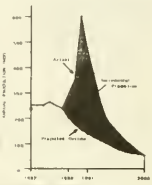
At **Vidor Ames Field** in the Expanded Yegua Trend of the Texas Gulf Coast, Gulf had drilled a wildcat in 1960 which produced a few thousand barrels of oil from a thin, poor-quality sandstone in the Yegua. This well "condemned" this formation and part of the trend for decades. Using new geological concepts of delta and strandplain formation during low-stands of sea level, Venus Oil made a case for sand development across major structures near and under the city of Vidor. High-quality seismic data was acquired through a partly urban area. The discovery well, drilled by Amerada Hess in 1989, found several hundred feet of high-quality sandstone, and produced at over 10 MMCF gas and 1000 barrels of condensate per day. One well was drilled less than 1500 ft from the old Gulf well, and is a prolific producer of natural gas (Figure 11). Today the field has produced over 38 BCF from ten wells, and flows at the rate of some 70 MMCF per day; total reserves could be 150 BCF.

A similar new-concept exploratory success is the **Ames Hole**, north-central Oklahoma, where geological identification of an unproductive anomaly as a meteorite impact crater was followed by 3D seismic interpretation and successful drilling of highly fractured Arbuckle and basement rocks; total reserves may reach 10 MMBO.

At **Trimble Field** in the Mississippi Salt Basin, significant gas reserves had been bypassed in two older wells. The productive character of the low-resistivity Eutaw sandstone reservoir was only determined in 1988 by modern geophysical logging and careful log evaluation. Reserves for the field, discovered by Cobra and Paramount, are estimated at 100 BCF, with 20 wells and production rates of 40 MMCF per day forecast (Cook and others, 1990). Similar bypassed and "log evaluation" fields are reported from **East Loving Field**, New Mexico and elsewhere.

Revolutionary advances in seismic reflection technology, including 3D seismic and workstation interpretation, have resulted in discoveries and reserve additions too numerous to mention. Significant discoveries are being made using 3D seismic in **Pennsylvanian Reefs** of West Texas, and in the **Williston Basin** of North Dakota and

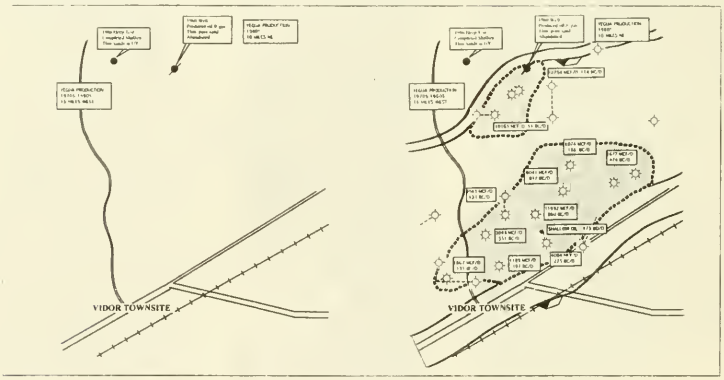
FIGURE 12. PRODUCTION CURVE, MCFARLAND FIELD, WEST TEXAS



Source: University of Texas, Bureau of Economic Geology (1992). New concepts in geological understanding of reservoirs has led to new drilling and large increases in production.

FIGURE 11. VIDOR AREA, ORANGE COUNTY, TEXAS

Note: Figure on left predrill (ca. 1988) and Figure on right (ca. 1992). New concept exploration resulted in numerous gas wells which contribute to the local, state and national economies.



Montana. Delineation seismic using 3D methods has been very successful, including **Hartburg field**, Texas and **Ames Hole**, Oklahoma. And the same methods have assisted targeted infill drilling in many Gulf Coast and MidContinent fields and trends.

In **Basin Fruitland Field**, New Mexico, advances in drilling and completion technology have been critical to very large gas reserve additions (Whitehead, 1991). Although this coalbed methane reservoir had been known since 1977, little production was obtained before 1985. Advances in drilling and completion technology, based on a better understanding of the nature of coalbed reservoirs, include extensive dewatering and cavity completions. These advances, combined with favorable tax credits, allowed Meridan Oil and other operators to profitably build the complex gathering and disposal systems required. As of 1991, there were 830 wells producing about 22 percent of total New Mexico production from the Fruitland coal. The recoverable gas resource in this field alone is 36-50 TCF. Similarly, advances in horizontal drilling, logging and completion have enabled the tremendous growth of the **Austin Chalk Trend**, Texas and Louisiana Gulf Coast; and advances in fracturing technology have reinvigorated the **Cotton Valley fields** of East Texas.

At **McFarland Field** and nine other fields in West Texas, advanced studies of reservoir architecture and well performance have been undertaken by the Bureau of Economic Geology. Its 1992 report analyzed the results of drilling by field operators based on these integrated geological and engineering studies. At McFarland (Queen) field, which was nearing the economic limit of recovery, targeted infill drilling increased production threefold to more than 600,000 barrels; total additional recovery is projected to reach 1.7 million barrels (Figure 12).

Similarly, **Emma (Ellenburger) Field** has yielded an incremental production of 560,000 barrels by recompleting wells in cave-floor breccias which lie slightly deeper than the previously productive reservoir. A total of 9.1 million barrels in additional oil recovery has been identified for the **University Lands fields**.

The Frontier Wildcards

The United States has an immense hydrocarbon frontier. The frontier consists of :

—basins which have not produced hydrocarbons;

—areas of producing basins which have not been adequately tested;

—deeper parts of producing basins, or downdip of known production; and

—unrecognized or "unconventional" reservoirs

Few of these frontiers are being actively pursued at present, largely due to the high risks associated with nonproducing trends and the very limited supply of capital. However, they are potentially critical, as they hide the remaining giant oil and gas fields of this country. Encouraging the formation of longer-term risk capital will have an especially important impact on these frontier plays.

Only an estimate, usually implicit, of the importance of these frontier areas was considered by the NPC gas and DOE oil studies. In truth, for many frontiers, the database is entirely insufficient to evaluate their hydrocarbon potential. Thus, significant additions to the resource base can result from frontier exploration.

Overall, some fifty basins or portions of basins in 38 states are judged by the IPAA Task Force to have possibly significant potential for future reserve addition (Table 4). This is not meant to be exhaustive nor predictive, but does indicate the scope of potential activity. In addition, one should take into consideration the "stumble factor." It has been said that more oil was found on wrong geology than right geology. Major new plays have often resulted from chance encounters on the way to a dry deep objective.

■ *Nonproducing basins*

We now know quite a bit about the principles of oil and gas generation and accumulation. To some extent, oil or gas may be found anywhere there is a sedimentary section present (yellow area on Figure 13). However, significant discoveries will only be made if there is: an organic-rich *source rock* which is or was hot enough to generate oil or gas, *reservoir rocks* which can store oil or gas, *seals* which can prevent oil or gas from escaping, and a *plumbing system* which allows oil or gas to get from source to reservoir. The known producing basins, by and large, are connected with known sources and certainly contain known reservoirs and seals.

Nonproducing frontier basins, such as those shown in purple on Figure 13, are areas of thick sedimentary accumulations which may contain the critical source, reservoir and seal relationships. Few of them are without any well penetrations; some are fairly extensively drilled. However, explorationists know how inconclusive a dry hole can be for condemning an area; this is shown, for example, in the IPAA survey results. Furthermore, each basin and trend has its unique style of hydrocarbon accumulation, determined by the relationships of source, reservoir and seal. Most basins had tens if not hundreds of penetrations before that style was determined and significant successes followed. Today we are somewhat more efficient, since we have better imaging and evaluation technology. Nonetheless it is presumptuous to write off a basin based on a small number of wells.

■ *Untested areas of basins*

Some known producing basins have portions which have not been tested. Sometimes this is due to depth. In other cases, it is due to land restriction (as in the offshore Southern California basins, which almost certainly have very major oil resources) or operational difficulties (such as the offshore Alaska North Slope).

■ *Deep basins*

The number of well penetrations falls off sharply with depth in every sedimentary basin. Thus, even a highly mature basin with wells every mile or less may be little explored and little understood at depth. This effect is enhanced if abundant shallow production has retarded deep drilling, as in the Panhandle-Hugoton gas field of the Texas-Oklahoma-Kansas area. The major Rose Run play of Ohio occurs at a shallow depth of 6000 ft, but still beneath the Clinton play; the shallower production had sheltered the deeper play for nearly 100 years. No basin can be considered thoroughly explored below 15,000 ft depth. The resource at greater depth, particularly for natural gas, can be tremendous.

TABLE 4.
SELECTED FRONTIER AREAS WITH POSSIBLY SIGNIFICANT POTENTIAL

Pacific:	
OR	Tyee-Willamette Basin (Tertiary)
WA	Chehalis Basin Area (Tertiary)
WA, OCS	Shoreline Washington (Tertiary)
WA, OR	Columbia Plateau Basin (Cretaceous, Tertiary)
CA, OCS	Monterey Fm Basins — CA Borderlands
CA	Deep onshore CA Basins
CA	Deep Great Valley Basins
CA , OCS	Eureka Basin and offshore extensions
CA, OR, WA OCS	Various offshore trends potential
AK	Deep Cook Inlet and Extensions (Susitna, Shelikof Basins)
AK	Alaska National Wildlife Refuge
AK	Offshore Beaufort Sea
AK	Chukchi Sea
AK	Navarin Basin
AK	Norton Basin
AK	St. George - N. Aleutian Basin
AK	Gulf of Alaska Basin
Rocky Mountain:	
NV	Central Nevada Trend
UT	Kaiparowits Basin (Precambrian sources)
CO, UT	Piceance Basin (Tight Gas)
NM, CO	Raton Basin (Coalbed Methane)
CO	San Juan Sag
MT	Disturbed Belt
MT	Central Montana Trough
ND	Southeast segment, Williston Basin
Mid-Continent:	
WI, MN, IA, KS	Mid-continent Rift
OK	Deep Anadarko Basin
OK, AR	Arkoma Basin
OK	Ouachita Basin
TX	Fort Worth Basin
TX	Kerr Basin
TX	Deep West Texas Basin
NM	Northwestern edge, West Texas Basin
NM	Orogrande Basin
Eastern:	
MA OCS	Offshore Georges Bank Basin
NJ OCS	Offshore Baltimore Canyon Basin
SC OCS	Offshore Carolinas Basin
NJ, VA, NC	Triassic Basins (Newark Supergroup)
NY, PA, WV, KY	Deep Appalachian Basin
KY, IL	Rome Trough - Rough Creek Trough
OH, KY	Middle Run Basin
MI, IN	"Albion Scipio Trend" Altered dolomites
Gulf Coast:	
FL, OCS	South Florida Basin
FL, OCS	Destin-Jay shelf edge trend (Apalachicola Basin)
LA, TX, OCS	Deep Gulf of Mexico Tertiary (general; many trends)
TX, LA, MS, AL	Deep Gulf of Mexico Mesozoic (general; many trends)

Note: OCS represents Outer Continental Shelf.

■ *Unconventional reservoirs*

As little as ten years ago, gas reservoirs such as coalbed methane or shale were not included in resource assessments, as they were "unconventional," not known to be economically recoverable by present technology. Now they are essential to America's natural gas production. What "coalbed methanes of the future" are there today? What new ideas are required to recognize these resources?

One resource of the future consists of *gas hydrates* — solid compounds of natural gas and cold water that form below the seabed in water depths of several thousand feet. Up to 5000 TCF of gas may exist in this form, dwarfing the conventional gas fields of the world. Mankind does not have the technology to commercially produce this gas — yet.

Another resource of the future consists of active migration — tapping the natural gas that is now being generated deep within sedimentary basins and is finding its way along fractures and faults upwards towards the surface. Recent studies have indicated some promise for major reserve additions in these unconventional environments (Anderson, 1993).

How to Realize the Resource

This report has summarized the resource base of the United States, and the present activity of the domestic oil and gas industry. The resource base studies show that we can meet our country's needs for natural gas for many years to come, and stem the increase in oil imports, through intelligent and efficient exploration and development. This production, particularly of clean-burning, environmentally-preferred natural gas, will provide the "bridge fuel" which the nation will need well into the next century.

But our country's needs can only be met through drilling. To convert the resource into reserves and production on the time scale needed by the American economy will require at least a doubling of industry effort; rotary rig counts in the neighborhood of 1,600, and upstream employment similarly scaled up. It will require the ability to form sufficient capital to mobilize these rigs and

10

create these jobs. And it will require governmental action to make the resource base accessible.

By following the road of *moderate growth,* the country will reap enormous benefits. Foreign oil imports can be stabilized, and the balance-of-payments deficit reduced. Up to 200,000 new jobs can be created (offsetting the 450,000 lost in the 1980s). The tax base will be increased substantially, as new wealth is brought from the ground. And, because of the widespread use of technology, our country's leading position in creating and supplying petroleum technology will be safeguarded and enhanced.

If America's goal is to double our efforts to find and produce natural gas and oil, industry, investors and government must all play a constructive role.

For *industry*, three standards must be achieved.

—First, industry must improve and apply today's and *tomorrow's technologies* to the exploration for and production of natural gas and oil. This means every company and every professional. Independents have often relied on "hand-me-down" expertise from major companies; this may not be as available in the future. Service companies, universities and the independents themselves must adapt and advance the petroleum-finding and producing sciences, through the process called "technology transfer."

—Second, based on this proven and widespread efficiency at finding and producing hydrocarbons, industry must *attract capital* from all sources into the E&P sector. Sources of capital must be sought from nontraditional sources, perhaps packaged in new and more useful ways. Partnerships with supply-conscious end users will form a significant part of this effort, along with more sophisticated use of financial and commodity markets.

—Third, the industry must *educate the public* on the need for gas and oil production. The American people must be assured that we can explore for and produce hydrocarbons with minimum disruption of the environment and that we will be good stewards of the earth. The benefits of the moderate growth strategy must be proclaimed and pursued.

Investors must consider that today is an unparalleled time of opportunity in the domestic oil and gas business. Despite the talking down which some industry members have engaged in, the U.S. is still a good place to invest. Infrastructure and markets are readily available. Finding and development costs for independents range around $5-6/barrel, comparable to overseas investment and significantly less than major overseas projects. Acquisitions are still slightly cheaper, about $4/barrel, but economically attractive projects in that market are hard to find and close. Increased efficiency of E&P due to new technology such as 3D seismic, horizontal drilling and reservoir characterization, should be maintained through the foreseen period of moderate growth. Good ideas are still available at reasonable prices, and general business costs are near the bottom of the cycle →

FIGURE 13.
AMERICA'S UNDEVELOPED NATURAL GAS AND OIL RESOURCES
Note: Shows existing producing areas, significant plays, survey responses, some significant frontiers, and total prospective areas.

TABLE 5. SUMMARY OF IPAA SURVEY RESPONSES

STATE	COUNTY	FIELD	RESERVOIR	PLAY	DEPTH	DISC.DATE	OIL RESERVES	GAS RESERVES	METHOD OF DISCOVERY— GEOL CONCPT?	GEOPH TECH?	DRLG TECH?	DPR PAY?	LOG EVAL?
AK	9N20E UM	Badami		Barrow Arch Oil	<12900	1991							
AK	12N14E UN	Pt. McIntyre	Kuparuk Ss	Barrow Arch Oil	8800	1989	300 MMBO						
AK	OCS Y86	Kuvlum		Beaufort Sea Oil		1992							
AK	11N10WSM	Sunfish	Tyonek Ss	Cook Inlet O&G	12160	1991							
AK	8N14W SM	W. McArthur R.	Hemlock Cgl	Cook Inlet O&G	13700	1991							
AL	Monroe	N. Frisco City	Haynesville Ss	Up.Jurassic Oil	12000	1991	40 MMBO	30 BCF	Y	Y-3D			
CO	Cheyenne	Arapahoe	Morrow Ss	LasAnimas Arch Oil	5700	1987	25 MMBO		Y-REG	Y			
KS	Barber	(Unnamed)	Miss. Chat	Kansas Shelf		1992	1 MMBC	20 BCF		Y			
KS	Barber	Lone Jom,S.	Miss.,Viola Ls	Kansas Shelf	4800	1972(1987)	750 MBO			Y	Y-FRAC		
KS	Finney	Stewart	Miss.,Morrow	Kansas Shelf	4850	1956(1985)	7.5 MMBO			Y			
KS	Kearny	Langdon	Miss. Chat	Kansas Shelf	shallow	1978(1990)	68 MMBO	19 BCF			Y-FRAC		
LA	Avoyelles	N. Bayou Jack	Austin Chalk	Austin Chalk Oil	15000	1991	7.5 MMBO?		Y	Y	Y-HZTL		
LA	OCS-Vars.	Upper Miocene	Up.Mio. Ss	Upp.Miocene G&O	4000	ongoing		15-30 BCF/FLD					
MI	various	Antrim Shale		Antrim Shale Gas	1500	ongoing		800 BCF					
MI	Otsego	Antrim Shale		Antrim Shale Gas	1500	1940 on							
MO	Atchison	Runamuck	Viola Ls	Forest City Basin		1987	500 MBO						
MS	Jones	Tallahoma Creek	Cotton Valley Ss	Miss.Basin Jur.Oil	16200	1990	2-5 MMBO		Y-CDMD	Y			
MS	Smith	Trimble	Tuscaloosa Ss	Miss.Basin UK G&O	7450	1988		100 BCF					Y
MT	Blaine	Kahlat Hills	Sawtooth	Hoagland Basin	4500	1972(1991)	800 MBO +						
MT	Roosevelt	Bainville N	Nisku Ls	Williston Ord.Dev	10000	1979(1992)	800 MBO +		Y				Y
ND	Billings	various	Tyler Ss (Penn.)	Williston Bsn Penn		1950s(1961)	160 MBO + all		Y				
ND	various	various	Madison Ls	Williston Bsn Miss		developing					Y-HZTL		
ND	Stark	Dickinson	Lodgepole Ls	Williston Bsn Miss	9721	1993	2.8 MMBO	1 well)1.4 BCF				Y	
ND	Ward,Renv	various	Sherwood Ls	Williston Bsn Miss	5500	ongoing			Y				
NE	Kimball	Kleinholz	Wolfcamp Ss	Denver Basin Pz	8300	1986	4.5 MMBO		Y	Y		Y	Y
NM	Eddy	East Loving	Delaware Ss	Delaware Ss Oil		1987	4.5 MMBO		Y				Y
NM	San Juan	Basin Fruitland	Fruitland Coal	San Juan CBM Gas		1977(1986)		36+ TCF	Y-REG		Y		
NM	Rio Arriba	NE Blanco Un.	Fruitland Coal	San Juan CBM Gas	3000	1988		800 BCF	Y		Y-PDN		
OH	various	Clinton Fm	Clinton Ss	Clinton Oil	3500	1987	113 MBO	630 MMCF					
OH	Holmes	Rose Run Trend	Knox Ss/Ls	Rose Run Gas	5500	1965(1983)	3+ MMBO	500 BCF?				Y	
OH	Holmes	Rose Run Trend	Knox Ss/Ls	Rose Run Gas	5500			0.7 BCF/WELL				Y	
OK	Beaver	Mocane-Laverne	Miss Ls	OK Shelf Oil	7500	ongoing							
OK	Carter	Cottonwood Creek	Arbuckle Ls	Ardmore Basin O&G	8700	1988	7.5 MMBO	6.8 BCF					
OK	Custer	Cherokee Gas Trend	Cherokee Ss (Penn)	Anadarko Bsn Penn.	11500	1974 on		3 TCF			Y		Y
OK	Major	Ames Hole	Arbuckle Ls. Gr	Astrololeme, OK	8600	1990	10 MMBO		Y	Y-3D			
OK	western	Putnam	Council Gv,Tonkawa	OK Shelf Oil	8100	1990	5.0 MMBOE		Y				Y
OK	Oklahoma	Cross Roads	Viola Ls,	OK Shelf Oil	7000	1905	3.37 MMBO	45 BCF	Y				
OK	Oklahoma	Bethany	HuntonLs,OilCk Ss	OK Shelf Oil	7000	1988	1.5 MMBO	12 BCF	Y-URB				
OK	Pawnee	Pawnee Lake	Red Fork Ss (Penn)	OK Shelf Oil	3600	1983	13 MMBO	50 BCF					
PA	Centre	Council Run	Up.Dev. Ss	Appalachian Basin	2000	1982 on		250 BCF					
TX-3	Brazoria	Manor Lake E.	Frio Ss	Oligocene G&O	10900	1988	400 MBC	80 BCF	Y	Y			
TX-3	Galveston	Three J	Frio Ss	Oligocene G&O	12600	1988	778 MBC	5.4 BCF				Y	Y
TX-3	Harris	Stella Road	Jackson,Vk Ss	Eocene, Olig. G&O	9050	1988	3.9 MMBO	12 BCF		Y			Y
TX-3	Lee &c	Giddings	Austin Chalk	Austin Chalk O&G	7000	981(1975+)	>>225 MMBO			Y	Y-FRAC,HZTL		
TX-3	Orange	Vidor Ames	Yegua Ss	Eocene G&O	13000	1989	10 MMBC	150 BCF	Y-REG,CDM	Y			
TX-3	Orange	Hartburg	Yegua Ss	Eocene G&O	13600	1991	5.6 MMBC	70 BCF		Y			
TX-3	Jim Hogg	El Mesquite	Cook Mtn. Ss	Eocene G&O	5200	1989	3.5 MMBOE					Y	
TX-G	Gregg	RCR	Pettet Ls	East Texas Basin	7300	1988						Y	
TX-6	Panola &c	Carthage	Cotton Valley Ss	East Texas Basin	6500'	1970 on		TCF+			Y-FRAC		
TX-7C	Concho	Lonesome Dove II	Kino Ss (Penn.)	Eastern Shelf Oil	2070	1989			Y	Y-GCHM			Y
TX-7C	Schleicher	various	Canyon Ss	Canyon Sand Gas	7000	ongoing		5/10 BCF/WELL			Y-FRAC		
TX-B	Andrews	S. Doyle'll	Qu,SA,Cl Ls/Ss	WTB Permian Oil	4000	1967(1990)	1 MMBO +		Y		Y		
TX-B	Andrews	Emma	Ellenburger Ls	WTB Lo.Paleoz.Oil	13300	1988 on	565 MBO +						
TX-B	Andrews	McFarland	Queen Ss/Ls	WTB Permian Oil	4790	1988 on	1.7 MMBO +						
TX-B	Ector	Kinglake	Ellenbrger,Dev Ls	WTB Lo.Paleoz. Oil	10900	1988	5 MMBO	1.5 BCF	Y-REG	Y			
TX-B	Ector	Harper	Glorieta Ss/Ls	WTB Permian Oil	5500	1988	2 MMBO					Y	
TX-B	Midland	Spraberry Trend	Spraberry Ss	Spraberry Trend	8500	ongoing	70 MMBO?						
TX-BA	Garza	Happy	Spraberry Ls	Spraberry Trend	7950	1988	3.5 MMBO						Y
TX-9	Grayson	Southmayd N.	Penn, Viola Ls	Ardmore Basin O&G	8300	1977(1982)	5 MMBO	12 BCF	Y				
WY	Powder R.	Minnelusa Trend	Minnelusa Ss	Powder River Bsn	8000	ongoing	1.4 MMBOIP/WELL?				Y		
WY	Powder R	Minnelusa Trend	Minnelusa Ss	Powder River Bsn	8000	ongoing	10 MMBO				Y-POLY		

NOTES ON SYMBOLS USED:

C-- Cost Sensitive
CDMD-- "Condemned" by Old Wells
CDNS-- Condensate in Gas
CO2-- Carbon Dioxide in Gas
DIR-- Direction Drilling Required
ECON-- Economics (Returns)
EXT-- Field Extension
FED-- Federal Lands
FRAC-- Fracturing Technology
GATH-- Gathering
GCHM-- Geochemistry
HIST-- Historical success
HZTL-- Horizontal drilling
LE-- Log evaluation
MD-- Mud disposal
OPNS-- Operations
P-- Price sensitive
PC-- Price and cost sensitive
PDN-- Production
PL-- Pipeline
PLANT-- Gas Plant
POLY-- Polymer Flood
RCRA-- RCRA Act Compliance
REG-- Regional Geology
REGS-- Regulations
RISK-- Risks
S-- Seismic
SOUR-- Sour Gas
SR-- Success Ratios
SWD-- Salt Water Disposal Co
TAX-- Taxes
3D-- 3D Seismic
URB-- Urban Area

FAVORING FACTORS-- GEOL	SEIS	LAND	TAX CREDIT	RESERV QUALITY	ORLG TECH	PRICE/ COST	MARKET	HINDERING FACTORS-- GEOL	LAND	ORLG	OPERNS	PRICE/ COST	MARKET	ENVIRON REGLNS	OPERATOR	REFERENCE
															Conoco	AKDOG
															ARCO	AKDOG
															ARCO	AKDOG
															ARCO	AKDOG
															Stewart	AKDOG
		Y		Y								Y-PLANT			Torch	Gulf Coast Oil World, 1992
Y				Y					Y				Y		Medallion	IPAA
				Y		Y-C						Y-PC			JW Woolsey	IPAA
						Y-C						Y-C			JW Woolsey	IPAA
		Y				Y-C	Y-RISK					Y-P			Sharon Res	IPAA
Y		Y		Y											Mach Pet	IPAA
Y	Y				Y			Y-LE		Y		Y-C			Cliffs	IPAA
	Y					Y-PC						Y-P	Y-PL	Y REGS	Santa Fe En.	IPAA
			Y		Y		Y					Y-TAX		Y Y-REGS	NOMECO	IPAA
			Y			Y-ECON						Y-TAX		Y Y-REGS	??	IPAA
															Anderson	MO DNR
Y	Y			Y				Y	Y-URB						Mallai (Nuecen)	IPAA
															Cobra/Paramount	Cook et al., 1990
Y	Y				Y-SR	Y-C		Y-LE		Y					Norfolk Energy	IPAA
						Y-ECON									Terra	IPAA
				Y					Y-FED						Amerada,Duncan	IPAA
		Y			Y-HZTL			Y-HIST			Y-SOUR					IPAA
Y				Y			Y	Y							Conoco	IPAA
Y		Y									Y-SOUR					IPAA
	Y			Y											Exxon	NI 65; Sabl et al., 1993
															RAMCO	IPAA
			Y	Y	Y			Y-CO2			Y-SWD,GATH				Meridian, etc	Whitehead, 1991
			Y	Y	Y				Y		Y-GATH			Y	Devon Energy	IPAA
Y	Y	Y-HBP					Y	Y-LE	Y-URB			Y-P		Y RCRA	Noble Oil	IPAA
	Y							Y	Y-HBP			Y-P		Y WLT	Belden&Blake	IPAA
															Anon.	IPAA
Y		Y									Y-PL	Y-P			Anon.	IPAA
Y	Y							Y-LE						Y MD	Mark Ltn (CNG)	IPAA
Y	Y-3D	Y-OPNS			Y			Y-S	Y-C			Y-C		Y-MD	Apache	IPAA
Y	Y-3D	Y		Y				Y-LE		Y	Y-SWD			Y-MD	Continental Res.	Carpenter & Carson, 1992
Y		Y						Y-LE						Y MD	Alexander Ltn.	IPAA
Y		Y			Y				Y-URB		Y-SWD,DIR				OXXCO	IPAA
Y		Y			Y				Y-URB	Y-DIR	Y-SWD				OXXCO	IPAA
															Henson Mn Gp	IPAA
		Y					Y	Y	Y					Y WET	Eastern Gp.	IPAA
Y	Y								Y	Y				Y-WET	Spartan	IPAA
Y-CONS						Y-C						Y-C			McClesky?	IPAA
Y						Y-C	Y		Y-URB,C			Y-C			Columbus En.	IPAA
Y		Y			Y	Y-C			Y-URB						Sage &c	IPAA
Y-CONS	Y			Y				Y-LE	Y-URB	Y				Y-WET	Amerada Hess	IPAA
Y-CONS	Y			Y			Y	Y-LE	Y-URB			Y-C		Y WET	Bridge, Exxon	IPAA
						Y-C				Y-FRAC					Hughes, &c	IPAA
				Y					Y-URB						R&C Pet.	Gulf Coast Oil World, 1992
Y			Y		Y		Y	Y				Y-C			UPRC &c	IPAA
Y-GCHM						Y		Y							Marshall&Wms	Powers and Waters, 1992
															various	IPAA
Y		Y													Sage	IPAA
Y															??	BEG, 1992
															??	BEG, 1992
															??	IPAA
Y						Y									Sage	IPAA
					Y										??	IPAA
								Y,Y-S	Y-C						Bennett Pet.	IPAA
		Y			Y		Y								Precision Op.	IPAA
			Y		Y										??	IPAA
															TIORCO	Hochandel et al, 1990

OIL AS A FINITE RESOURCE: WHEN IS GLOBAL PRODUCTION LIKELY TO PEAK?

James J. MacKenzie
March 1996

SUMMARY

Fossil fuels -- oil, natural gas, and coal -- account for the vast bulk of global energy supply. These fuels, formed over millions of years, are finite and non-renewable. In due course, they will become scarce and costly, requiring the introduction of replacement energy sources. The role of fossil fuels in powering modern economies is so vital as to warrant a review of ultimately recoverable reserves and of plausible future consumption patterns. So doing will help decision-makers determine when replacement sources and new technologies might be needed. As a starting point in such a process, future supplies and consumption patterns of crude oil are assessed here.

Over the past fifty years, many oil companies, geologists, governments, and private corporations have performed scores of studies of Estimated Ultimately Recoverable (EUR) global oil. (EUR oil is the total amount of oil that will eventually be pumped from the earth.) Taken together, the great majority of these studies reflect a consensus among oil experts that EUR oil reserves lie within the range of 1,800 to 2,200 billion barrels. As of the end of 1995, the world had consumed about 765 billion barrels of these ultimately recoverable reserves.

Given these estimates of recoverable oil, and plausible assumptions of moderate growth in demand (about 2 percent per year), we can use a simple model to calculate when world oil production might begin to decline, driven by resource constraints. At the low end, for EUR oil equal to 1,800 billion barrels, peaking could occur as early as 2007; at the high end (2,300 billion barrels), peaking could occur around 2014. (An implausibly high 2,600 billion barrels for EUR oil would postpone peaking only another five years -- to 2019.) If oil demand were held constant at today's level -- through some such measure as a carbon tax or a cap on carbon releases -- the time of decline could be delayed by decades.

As the peak of global oil production approaches, world oil prices will rise from their present low levels, though by how much and how fast remain uncertain. The economic impacts will depend largely on the

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price and availability of energy alternatives. The transportation sector, almost totally dependent on oil, could be especially hard hit unless vehicles fueled by sources other than petroleum are developed and rapidly deployed. As the peak and decline of world oil production comes within sight, policies to encourage more efficient oil use and a switch to alternative energy sources, especially in transportation, become urgent. Unfortunately, because oil prices are low, few decision-makers appreciate how little time remains, and efforts on both of these accounts are weak and overdue.

INTRODUCTION

Energy is the lifeblood of the world's economy, the underlying means by which modern societies function. Oil, coal, natural gas, and electricity are needed for virtually every important function in industrial societies -- from growing and cooking food, to manufacturing, heating and cooling buildings, and moving people and goods. The interruption of supplies by storms, earthquakes, wars, or other events quickly demonstrates how totally dependent we have become on the energy-consuming machines.

FOSSIL FUELS -- THE NON-RENEWABLE RESOURCES

In 1994, fossil fuels were used to meet over 85 percent of global commercial-energy demand.[1] (See Figure 1.) In energy terms, oil makes the single largest contribution to world energy supply, at 38 percent, followed by coal at 26 percent and natural gas at about 22 percent. Non-renewable, fossil fuels take millions of years to form, so for all intents and purposes they are finite and, ultimately, exhaustible energy resources.

While few would deny that the consumption of fossil fuels will eventually lead to their exhaustion, how and when the various fuels will decline remain uncertain. The debate over *conventional crude oil* is of especially great interest because of its dominant role in global energy supply.*

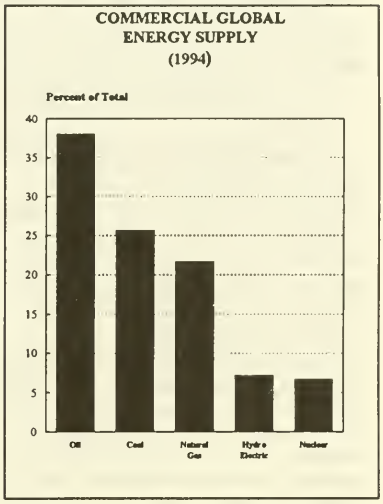

Figure 1

* *By "conventional crude oil" we mean the great bulk of crude oil produced today including that produced using enhanced oil recovery (EOR) techniques but excluding natural gas liquids, the very heavy Canadian tar sands, and the heavy oil found in the Orinoco deposits in Venezuela. Conventional crude oil is sometimes categorized as that producible at costs of $30 per barrel or less. It is estimated that, for non-OPEC producers, up to 70 percent of oil resources could be developed at less than $20 per barrel, and 90 percent at less than $30 or so. Similarly, at least 90 percent of Persian Gulf oil can be produced at less than $5 per barrel. Source: Terry Adams, "World Oil Reserves, Charting the Future," Middle East Well Evaluation Review, Number 10, 1991.*

Since world oil prices are relatively low (Figure 2), so is international interest in when worldwide oil production might peak and begin its inevitable decline. There are, nonetheless, geology-based arguments suggesting that global oil production may be only a decade or so away from this turning point. **When**, not **if**, peaking occurs, major new sources of energy will have to be introduced quite rapidly. The squeeze will be felt first in global transportation -- which is virtually totally dependent on petroleum.

While most analysts acknowledge the inevitability of a peaking in global oil production, some doubt that such a downturn will occur anytime soon. "We've heard it all before," is a typical reaction to the possibility. "For years Cassandras have been saying the world is running out of oil. But prices are low, proven reserves are large, and, at today's production rates, oil will last over 40 years," is another. While an element of skepticism is warranted, evidence for concern is far stronger today than ever before, partly because nearly all promising sedimentary basins worldwide have been explored to one extent or another. All who depend on oil need to bring an open mind to this accumulating evidence.

One recent indication that trouble lies ahead can be found in the International Energy Agency's (IEA) **World Energy Outlook, 1995**. In this report, IEA projects that world petroleum demand will grow in the range of 35 to 39 percent, relative to 1994, by the year 2010 -- about 2-percent growth per year. To meet this demand, IEA assumes that non-OPEC production will continue to rise -- by 3 to 18 percent by 2010 -- and that OPEC will make up the difference. Under this scenario, OPEC

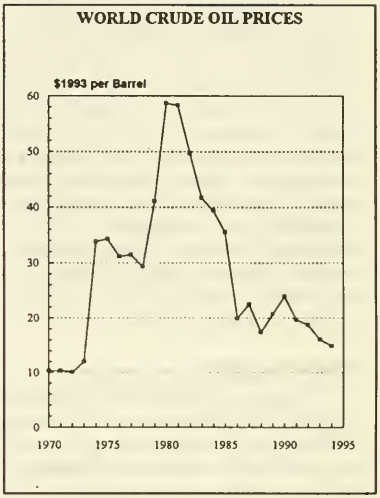

Figure 2

production -- principally in Saudi Arabia, Iran, Iraq, Kuwait, and the United Arab Emirates -- would have to increase by about 21 million barrels per day by 2010, from 27 to about 48 million barrels per day, 50 percent greater than the historical peak set in 1977. Yet, according to petroleum geologist Joseph Riva of the Congressional Research Service, planned expansion of production in these five major producing countries will fall some 10 million barrels per day short of the required goal.[2] Riva concludes that the

> "planned oil production expansions...are less than half that needed to meet the 2010 world oil demand projected by IEA, but will cost in excess of $100 billion, plus an additional $20 billion to upgrade and expand Persian Gulf refineries to

> meet growing world product demand. Oil production expansion beyond that planned would be even more expensive, on a per-barrel basis, as the remaining oil becomes more difficult to recover and enhanced oil recovery projects are required."

To complicate such supply issues, worldwide production will have to shift to Middle Eastern countries as global peaking approaches. In 1995, OPEC accounted for about 41 percent of world oil supply. By 2010, this percentage could reach 53 percent. -- essentially the same share OPEC had in 1973 at the time of the Arab oil embargo.[3] The principal OPEC suppliers will be Venezuela and the Middle Eastern giants: Saudi Arabia, Iran, Iraq, Kuwait, and Abu Dhabi.[4] According to the Oil & Gas Journal,

> "...only OPEC countries have room for production capacity growth sufficient to deal with all anticipated increases in petroleum demand. OPEC, especially Middle East OPEC, is where the monster reserves are..."[5]

With the strengthened position of Persian Gulf producers will come the increased economic and security risks associated with this volatile region. While difficult to quantify in economic terms, the risks are real to those heavily dependent on oil from the region. And in the longer term, this will mean virtually everyone.

Consumers everywhere will feel the peaking of global oil production. In particular, peaking will register with the developers, manufacturers, and owners of motor vehicles, since nearly all vehicles today are powered by petroleum products. Indeed, cars, trucks, buses, and other motor vehicles account for about a third of global oil use, 40 percent of oil use in the OECD countries, and about half of oil use in the United States.[6]

SOME OIL TERMS DEFINED

PROVED RESERVES are the confidently estimated amounts remaining to be produced from a known discovery as of a reference date, assuming current or foreseen economic and technological conditions.

CUMULATIVE PRODUCTION is the total amount of oil that has been produced from a well, field, basin, country, etc. up to the reference date.

ESTIMATED ULTIMATELY RECOVERABLE OIL (EUR) is the Cumulative Production when production is finally abandoned.

ANNUAL PRODUCTION OF A NON-RENEWABLE RESOURCE

The annual production of a resource such as crude oil depends on several factors including the known amount of oil still in the ground, the cost of extracting it, and the availability and price of global alternatives. In the simplest case, where alternatives are considerably more costly to produce, annual production would be expected to rise over time as the large oil fields are discovered and the technology of consumption (such as

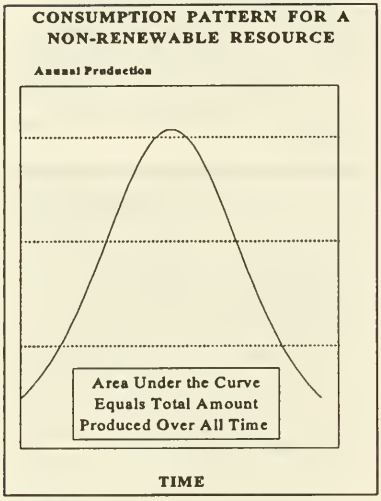
CONSUMPTION PATTERN FOR A NON-RENEWABLE RESOURCE
Annual Production
Area Under the Curve Equals Total Amount Produced Over All Time
TIME

Figure 3

motor vehicles) are developed and deployed. Eventually, older fields reach their peak and production begins its inevitable decline. During the decline, technologies such as water flooding and gas injection may be introduced to slow the rate of depletion of older fields. Meanwhile, exploration continues for new oil fields. Eventually, though, new fields become too small and economically not worth developing. Overall production continues to fall, and substitutes less costly than crude oil are developed and introduced. In the case of the coterminous 48 states (the "lower-48" states in oil-industry language), imported oil turned out to be the cheapest and most convenient replacement source when production began its decline in 1970.

Figure 3 shows schematically in the simplest of cases how annual production might look. Note that the area under the curve -- i.e., the sum of annual production for all years -- is equal to the total amount of oil that will be produced over all time, the Estimated Ultimately Recoverable oil. Figures 4 and 5 show the actual production data for the lower-48 states and Alaska. The smooth curves are "best" fits to the annual production data using simple bell-shaped curves.

If annual oil production follows a simple curve like Figure 3, then cumulative production -- the total amount of oil produced to date -- should follow a simple "S" shaped curve (like a logistic curve) that would eventually level off at the value of the ultimately recoverable oil. As Figures 6 and 7 show, the data for cumulative consumption

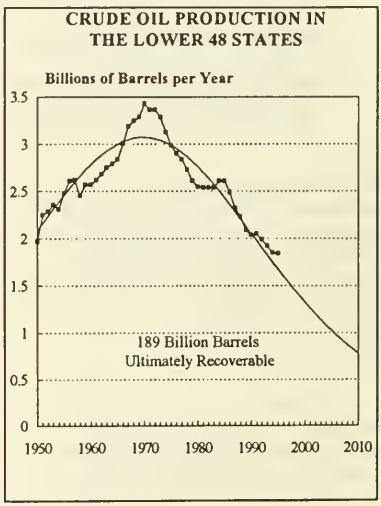

Figure 4

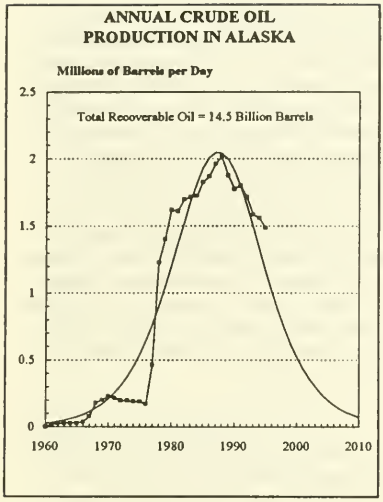

Figure 5

do indeed closely follow such simple curves. Ultimately, these curves suggest, recoverable crude oil in the lower-48 will total about 190 billion barrels (bbl). Of this amount, 160 billion (84 percent of the total) had been produced by December 1995. For Alaskan oil fields, about 14 billion barrels will ultimately be produced, of which 12 billion (86 percent of the total) had been produced by the end of 1995.

The conceptual basis for the simple model of oil production outlined here was reviewed in some detail by Cleveland and Kaufmann, both researchers at Boston University's Center for Energy and Environmental Studies.[7] They noted that the model does not explicitly take economic factors into account but that the overall pattern (in Figure 4) of annual production was correct. Deviations between predictedand actual production could, they assert, be explained largely by considering political events and changes in world oil prices. They also state that the bell-shaped model embodies the long-run effects of technical change and resource depletion and that this empirical approach has proven more accurate in its predictions than many econometric and geological models.

Cleveland and Kaufmann concluded that there is no *a priori* reason why oil production should follow such a smooth, symmetric bell-shaped curve. And, indeed, the global oil data shown in Figure 8 do not; what they do reflect is the political and economic turmoil of the past two decades. In particular, the price shocks of 1973 and 1979 contributed to economic disruptions

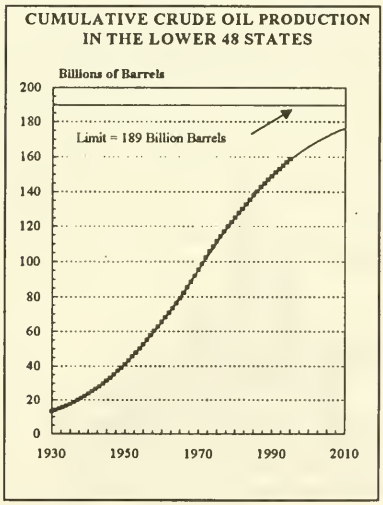

Figure 6

and the substitution for oil in some countries of natural gas, coal, nuclear power, and increased efficiency.

To gain some insight into roughly how much oil remains to be produced in the world, and how global production might evolve over the next few decades, we examine various estimates of global ultimately recoverable oil.

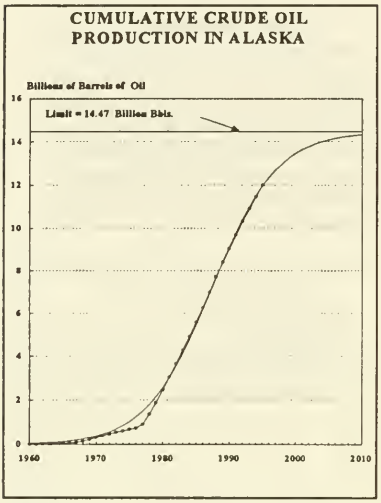

Figure 7

ESTIMATED ULTIMATELY RECOVERABLE (EUR) OIL

For many years geologists and oil companies have published estimates of the total amount of crude oil that will ultimately be recovered from the earth over all time. Remarkably, these assessments of Estimated Ultimately Recoverable (EUR) oil have varied little over the past half century. Figure 9 lists 41 estimates dating from the early 1950s.[8] For the past 25 years, with only two exceptions, estimates have ranged from around 1800 billion barrels to around 2400 billion barrels. David Woodward, General Manager of the Abu Dhabi Company for Onshore Oil Operations, also analyzed 40 estimates of ultimately recoverable oil, all published between 1975 and 1993. According to Woodward, "there is a fair degree of consistency among the estimates, with the average value being 2000 billion bbl [barrels] and most [70 percent] falling in the range of 2000 to 2400 billion bbl."[9] (See Figure 10.)

One widely cited assessment of EUR oil is the recent estimate (1994) of the U.S. Geological Survey (USGS), 2300 billion barrels.[10] In its analysis, the USGS provides

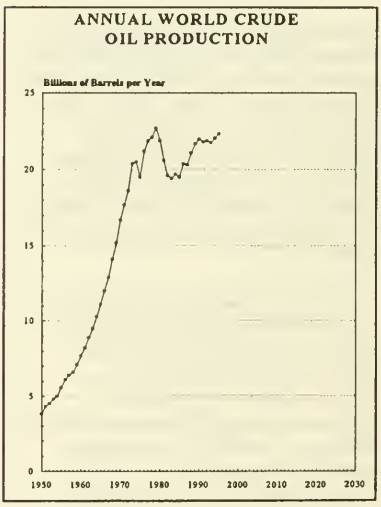

Figure 8

very optimistic estimates for recoverable oil for both the former Soviet Union (FSU) and China, two countries with potentially large oil reserves. For the FSU, the Survey estimates ultimately recoverable oil at 344 billion barrels (about 15 percent of USGS's world total). Of this, 225 billion (two thirds) remain to be produced and 100 billion are still to be found. China's estimated ultimately recoverable oil is given as 84 billion barrels, of which 67 billion (80 percent) remain to be produced and 30 billion to be found. In short, the USGS believes that both countries possess considerable amounts of still undiscovered recoverable oil.

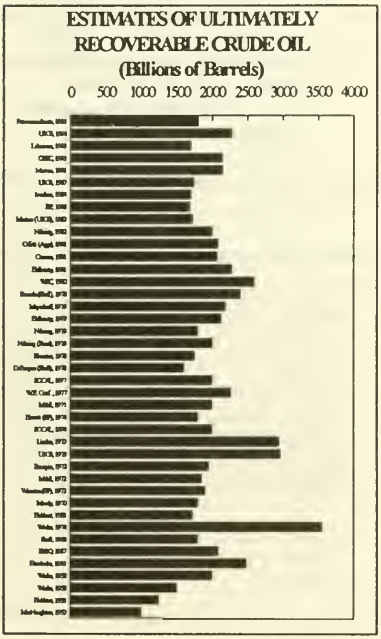

Figure 9

At the other end of the spectrum are far more modest estimates for the EUR oil in these two nations. Geologist Colin Campbell, of Petroconsultants, a Geneva-based consulting firm specializing in global oil and gas data, believes that the EUR oil in the FSU totals only two thirds as much as the USGS estimates. His estimate for China's ultimately recoverable oil is only 60 percent of the USGS estimate.[11]

Regardless of which estimate ultimately proves correct, there is considerable debate as to whether the crude-oil reserves of these two countries can be converted into high levels of production. According to a recent review of global energy resources by the World Energy Council (WEC), more than 85 percent of the

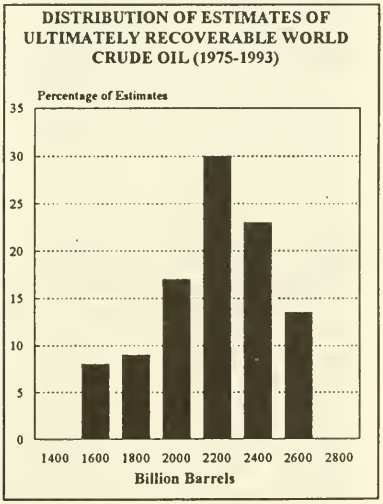

Figure 10

FSU's oil is in Russia, where production has been declining since 1990 for financial and other reasons and may recover only slowly.[12]

M. KING HUBBERT

The approach used here to estimate the date of peaking in oil production is based on the techniques first employed in 1956 by the late American geophysicist M. King Hubbert. According to Hubbert, in 1956 the "consensus among petroleum geologists" was that the amount of crude oil likely to be produced in the lower-48 states and off-shore waters was between 150 and 200 billion barrels.[a] From this, Hubbert calculated that production would peak between 1965 and 1970. Some 24 years after he made this estimate, Hubbert observed that "The initial reaction to this conclusion was one of incredulity--the man must be crazy!" In fact, U.S. production in the lower-48 peaked in the range predicted, in 1970, and annual production has since followed rather closely the curves Hubbert drew some 40 years ago. In the same 1956 paper Hubbert estimated that world oil production could peak around the year 2000. In 1981, Hubbert reviewed 12 recent estimates of ultimately recoverable crude oil, ten of which indicated a range of 1,500 to 2,500 billion barrels. Taking an average of 2000 billion barrels, he calculated world crude oil production would peak around the turn of the century, a value close to what we estimate here.

[a]M. King Hubbert and David H. Root, "Outlook for Fuel Reserves," McGraw-Hill Encyclopedia of Energy, 1981.

WEC estimates that to stabilize production at 1992 levels by 2000 would require an investment of $25 billion. In China, despite significant exploration efforts, especially in the Tarim Basin, reported proved oil reserves remain unchanged year after year. Production in China is expected to grow by a modest 1.4 percent per year through 2000.[13]

The majority of independent assessments of global oil have reached estimates roughly comparable to those displayed in Figure 9. Nehring (Rand Corporation) concluded that EUR oil lies between 1600 and 2000 billion barrels.

> "With improvements in oil recovery technology, ultimate resources could increase to as much as 2400 billion barrels. This range corresponds to the consensus of estimates of conventional world oil resources developed since 1970."[14]

OPEC itself estimates ultimately recoverable oil at 2138 billion barrels.[15] Riva concludes

> "...when discoveries are plotted through time, it is seen that no super-giants have been found for more than a decade...This is a direct result of the global data base reaching maturity. It is unlikely that such major finds will ever be found in the future. It is a fact of exploration life that any obviously large structures have already been tested."
>
> *...Terry Adams, General Manager, Abu Dhabi Company for Onshore Operations, 1991.*

that EUR oil is about 2330 billion barrels.[16] Employing a geological model, Campbell and Laherrere (Petroconsultants, Geneva) calculate that EUR resources are no more than 1800 billion barrels.[17]

Why are estimates converging? Great strides have been made during the 20th century in the science of identifying promising areas for exploration. Such technological advances as analog reflection seismic (1935), mud logging (1940), digital reflection seismic (1965), and 3-D digital reflection seismic (1978)[18], combined with basic scientific progress in understanding plate tectonics and oil formation, greatly expanded the chances of finding new oil deposits. According to petroleum-geologist Campbell, "large tracts could now be confidently written off as non-prospective" if they failed to meet the now understood and essential criteria for successful oil discovery.[19] Petroleum consultant L.F. Ivanhoe argues that world petroleum exploration is now mature. The oil industry's years of hindsight and disappointing new-field discovery record during the great drilling surge between 1978-86, combine to yield sobering results, he concludes. No new major oil provinces have been found or developed for several decades. Indeed, according to the USGS, global discovery of *new oil fields* peaked in 1962 and has been declining since.[20] To date, many lightly drilled basins were found to be barren or only marginally commercial, and, according to Ivanhoe, new giant field discoveries are most likely to be found where large fields are already known -- in the Persian Gulf and Venezuela. Few giant discoveries are expected in the critical non-OPEC oil exporting countries.[21] Campbell, of Petroconsultants, draws similar conclusions: "By now, the whole world had been thoroughly explored so it has become clear that no new provinces comparable with the North Sea and Alaska await discovery..."[22] The net result of lagging discoveries is the inevitable decline in producible oil: while world crude oil demand is about 22 billion barrels per year and rising, the amount found *in new fields* per year is less than 10 billion barrels and falling.

> "It now seems unlikely that the world contains any really major (more than 15 BBO [Billion Barrels of Oil]) undetected petroleum provinces. The exploration industry now has an almost global knowledge of sedimentary basins and the geological factors that are required for major success are well understood. ...Notwithstanding a very significant exploration effort by the industry, no new major oil provinces have been established since the North Sea in the late 1960's and the Reforma/Campeche region in Mexico in the early 1970's."
>
> *...Dr. D.A.L. Jenkins, General Manager, Exploration, British Petroleum Co. in Petroleum Review, December 1987, p. 15.*

Evaluating these conclusions, some might argue that there are insufficient financial incentives to explore for new oil fields because world proved reserves are already quite ample. In a world awash in oil, they ask, why go looking for more? This

viewpoint was recently implied in an article in the Economist:

> "Proven reserves of oil are now enough to supply the world for 43 years at current rates of production..."[23]

Unfortunately, there are two holes in this argument. First, for political reasons, today's reported global proved reserves may be substantially overstated. Second, even though reserves may equal 43 times annual production (that is, a Reserves-to-Production ratio of 43 to 1) there is no basis for believing that production can be held constant for 43 years.

First, consider politics. Although the Oil & Gas Journal reports 1995 proved reserves at about 1000 billion barrels (of which two thirds are reportedly in the Persian Gulf), this estimate -- the product of reports from the various oil-producing countries -- may be artificially high. In the early and mid 1980s, world proved crude oil reserves ranged between 650 and 700 billion barrels. Beginning in 1985, OPEC members reported huge increases in their reserves, virtually overnight.[24] (See Figure 11.) In January 1985, Kuwait reported an increase of 41 percent. In January 1988, Abu Dhabi and Dubai each reported a tripling in their reserves; and Iran, Iraq, and Venezuela, a doubling each. In January 1990, Saudi Arabia reported a 50-percent increase. According to Campbell, of Petroconsultants, these "huge unsubstantiated increases" are "political reserves" and are more related to OPEC quota negotiations than to technical re-evaluations.[25] To muddy matters further, these "political reserves" -- amounting to about 300 billion barrels and accounting for a third of world proved reserves -- have remained exactly the same year after year despite substantial oil production from them. Clearly, the large increases (300 billion barrels) in OPEC reserves reported in the late 1980s should be questioned.

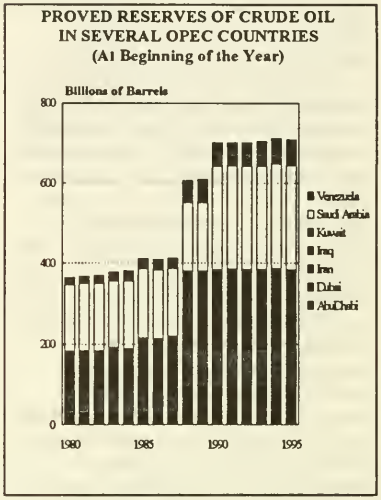

Figure 11

As for R/P ratios, oil does not flow freely from a large container marked "proved reserves." Rather, each field has an optimal range of production (depending on the size of the oil field and other considerations) which, if continuously exceeded, will jeopardize the field's long-term productivity. In short, maintaining production at a constant annual rate would require continual additions to reserves. This truism is clearly illustrated in the history of the lower-48 states. In 1970, when crude oil production hit its peak, reserves stood at 29 billion

barrels and the reserve-to-production ratio was 8.4 years. In 1978, eight years later, reserves had plummeted by 35 percent from their 1970 value and production had declined by 20 percent. In no sense was a reserves-to-production production ratio of 8.4 years in 1970 sufficient to maintain production constant at the 1970 rate.

But is this rather obvious fact the whole story? Economists argue that as oil scarcity takes hold, prices will rise, creating greater incentives to find new oil fields and increase recovery factors. This is certainly true. But, the record of both U.S. and global oil exploration shows only marginal results. From the early 1970s to the mid 1980s, when world oil prices were veryhigh -- $30 to $58 per barrel, in 1993 dollars -- exploratory and development wells in the United States increased dramatically, from 28 thousand in 1973 to a peak of 90 thousand in 1981. A high level of exploratory activity persisted until world oil prices crashed in 1986. Yet, during this entire period, proved reserves in the lower-48 states declined, from 25 billion barrels in 1973 to 20 billion in 1986, and crude oil production declined by 24 percent. Presumably, reserves and production would have declined even faster had oil prices remained low. As already indicated, during the 1970s and 1980s, global exploration by national oil companies increased dramatically with few new giant fields found. Indeed, according to Shell International, "Although world reserves have risen by 65 per cent since 1970, nearly all of these giant fields were discovered before that date."[26]

If the geologists cited here are correct and most of the major oil fields containing most of the oil have already been found, then increased exploration will, at best, identify only the few remaining major fields and a larger number of smaller ones. While helpful, these smaller fields will not be able to offset the long-term exhaustion occurring in the relatively small number of very large fields. Increased recovery in older fields will also help slow the decline in production; including higher estimates of ultimately recoverable oil is one way to represent this effect.

R/P [Reserves to Production] ratios, quoted in years, as a measure of security of supply, mislead and confuse people...an R/P ratio of 42 years...does not mean that current production can be sustained for 42 years--far from it.

...Petroleum Geologist C.J. Campbell, October 1995

...taking the *Oil & Gas Journal* world reserve number of 1,000 Gb and current production of 22 Gb...gives an R/P ratio of 45 years. This is extremely misleading because it suggests that present production can in fact be sustained for 45 years, which is clearly absurd. All oil fields decline during the second half of their life, and so current production can be sustained only if new discovery matches production.

...Petroleum analyst Jean H. Laherrere, February 1995.

13

SIZE DISTRIBUTION OF OIL FIELDS

Oil has been explored for and pumped from the earth for well over a century and the results have been impressive: over 41 thousand oil fields have been discovered worldwide. By no means are all of these fields of comparable size, however. (See the Table.)

Of the fields found so far, three quarters (31,000) are in the United States while only 537 are in the Middle East.[27] Both of the two Megagiant fields (more than 50 billion barrels ultimately recoverable) are in the Middle East, one in Saudi Arabia and one in Kuwait. Of the forty Supergiant fields (containing between 5 billion and 50 billion barrels) discovered, one is in Alaska and one is in the lower 48 United States. Of the 328 Giant fields (500 million to five billion barrels) found, 46 are in the United States.

TABLE
DISTRIBUTION OF WORLD OIL FIELDS BY SIZE

EUR (Million Barrels)	SIZE	U.S.	World Total
50,000+	Megagiant	None	2
5,000-50,000	Supergiant	2	40
500-5,000	Giant	46	328
100-500	Major	240	961
50-100	Large	327	895
25-50	Medium	356	1,109
10-25	Small	761	2,128
1-10	Very Small	4,599	7,112
0.1-1	Tiny	9,533	10.849
0-0.1	Insignificant	11,021	11,751
0-0.5	Other Tiny	4,500	5,989
TOTAL		31,385	41,164

Source: L.F. Ivanhoe and G.G. Leckie, "Global Oil, Gas Fields, Sizes Tallied, Analyzed," Oil & Gas Journal, Feb. 15, 1993, pp. 87-91.

The importance of the gigantic oil fields in global oil supply cannot be overemphasized. The 370 known oil fields containing 500 million barrels or more account for an estimated three quarters of all recoverable oil but less than one percent of the total number of fields.[28] The 1331 largest discovered oil fields -- each containing 100 million barrels or more of ultimately recoverable oil -- account for 94

percent of all discovered oil but only 3 percent of all oil fields. At the other end of the spectrum, the 39,833 smaller fields contain only 6 percent of the crude oil that will ultimately be recovered.

The implications of this skewed distribution are aptly summarized by Riva: "... most oil is contained in a few large fields, but most fields are small...as exploration progresses, the average size of the fields discovered decreases as does the amount of oil found per unit of exploratory drilling. In any region, the large fields are the biggest targets and are usually discovered first."[29] In other words, exploration in the declining phase of oil development is a far different game than in the early phase. In the early stages, it is the large fields that are readily discovered; in the declining stages, geologists are much more likely to find small fields and oil companies must do a lot more drilling just to stay even.

PLAUSIBLE SCENARIOS FOR FUTURE GLOBAL OIL PRODUCTION

Based on a range of assumed amounts of ultimately recoverable oil, what are some possible global oil production scenarios? We have seen a near consensus that EUR oil ranges from 1800 to 2200 billion barrels, with a few below and a few above this range. (See Figures 9 and 10.) (For perspective, in January 1996, cumulative world crude oil production had reached about 764 billion barrels.) Although the likelihood of such an increase is tiny, extending the high end of the range from 2200 to 2600 billion barrels shows how little difference a larger resource base would make in long-term global production.

Figure 12 shows five possible future courses for world crude oil production. Each production scenario passes through the **actual** production value for 1994 (22 billion barrels) and the U.S. Department of Energy's projection for the year 2000 (25.1 billion barrels).[30] The area under each curve -- from the beginnings of the oil era in the middle of the 19th century to the far distant future -- is equal to the indicated amount of ultimately recoverable oil. Since an infinite number of curves meeting these criteria could be drawn,those presented here simply illustrate the possibilities.

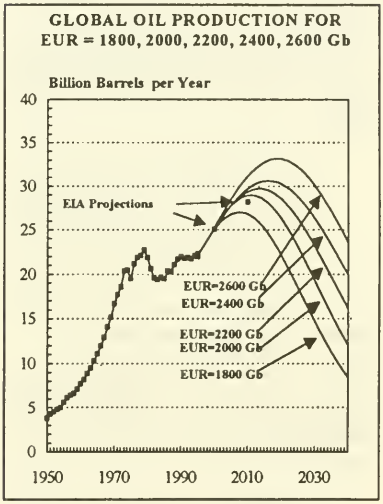

Figure 12

As Figure 12 shows, if ultimately recoverable oil is only 1800 billion barrels, then global production could peak by the year 2007. Even if EUR oil is as high as

2600 billion barrels, the year of peaking would move back only 11 years, to 2019. The dependence of the year of peaking on the volume of ultimate resources is shown in the lower curve in Figure 13.

A number of knowledgeable analysts have come to conclusions similar to those reached here. Jean Laherrere of Petroconsultants estimates ultimate global resources at 1750 billion barrels and calculates that world production will peak around the year 2000 at about 66 million barrels per day, followed by a decline of 2.7 percent per year.[31] Campbell, assuming 1800 billion barrels, also projects the peaking will occur around the year 2000. John F. Bookout, retired president and CEO of Shell Oil Company accepts the USGS estimate of EUR oil as consistent with those of Shell and agrees that world oil production will soon peak:

> "Oil production is projected to continue to grow in the near term at a rate of about 1 percent per year to a peak of about 75 million barrels a day around the year 2010."[32]

In a long-term look at the global oil industry, David Woodward, General Manager of the Abu Dhabi Company for Onshore Oil Operations, agrees with the IEA that only heroic increases in Middle East oil production could postpone a decline in world production:

> "... if we find only the lower limit of ultimate reserves (2,000 billion bbl), and the Middle East decides not to increase its output to more than twice the current level, the 1.5 percent assumed growth in world oil supply cannot be maintained much beyond the year 2000...if the upper estimate of ultimate reserves (2,400 billion bbl) proves to be the case, and the Middle East countries are prepared to increase their production three-fold, then the 1.5 percent growth in oil supply could be maintained until 2010."[33]

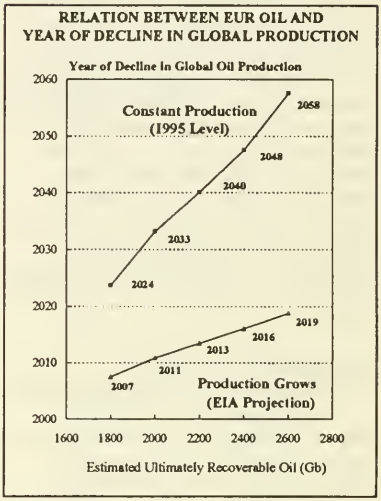

Figure 13

What role might energy conservation or fuel substitution play in delaying the time till decline? For various values of EUR oil, Figure 13 (upper curve) also shows the estimated year when global production would begin to decline **from present levels** if global oil production were held constant at 1995's level. If EUR crude oil totals only 1,800 billion barrels, 2024 would be the year of decline (from 1995's production level)

rather than 2007 (with growth in demand along the lines of the EIA's reference projection). The difference is 17 years. If EUR oil totals 2,600 barrels, the year of decline would occur around 2058, nearly four decades later than with growth. The clear implication of this simple analysis is that -- at a price -- some of the dislocations that otherwise lie ahead could be mitigated for a significant period of time if growth in global oil demand could be reduced or stopped. Note that, with the moderate-growth scenarios, production would be much higher at the point of decline than in the case of constrained production.

The daunting problems of expanding oil production may be dwarfed by the political and technological difficulties posed in holding oil demand constant to postpone the decline. If every oil-consuming nation held its consumption constant, the greatest burden would fall on the non-OECD countries (where per capita oil use today is only 14 percent that of the OECD countries). The US DOE projects non-OECD nations will increase their demand for oil by more than half by 2010 (an increase of 13.7 million barrels per day), compared with a 20-percent increase among the OECD countries (8.3 million barrels per day).[34] Only if the OECD countries **reduced** their oil consumption by about 2.26 percent per year could the non-OECD countries **increase** their consumption as projected (2.43 percent per year) and still achieve net zero growth in global oil demand over this period. Given the demonstrated problems in holding world carbon-dioxide emissions constant in response to global warming, the prospects for restraining oil use, especially in the transportation sector, seem dim.

This analysis does not imply that the world will soon "run out" of oil or hydrocarbon fuels. Oil production will continue, though at a declining rate, for many decades after its peak, and there are enormous amounts of coal, tar sands, heavy oil, and oil shales worldwide that could be used to produce liquid or gaseous substitutes for crude oil, albeit at higher prices.[35] But the facilities for making such synthetic fuels are costly to build, and environmentally damaging to operate, and their use would substantially increase carbon-dioxide emissions (compared to those from consuming products made from conventional crude oil).

Two important conclusions emerge from this discussion. First, if growth in world demand continues at a modest 2 percent per year, production could begin declining as soon as the year 2000. Second, even enormous (and unlikely) increases in EUR oil buy the world little more than another decade (from 2007 to 2018). In short, unless growth in world oil demand is sharply lower than generally projected, world oil production will probably begin its long-term decline soon -- and certainly within the next two decades.

CONCLUSIONS AND POLICY IMPLICATIONS

No one knows, of course, what will happen year by year to world oil prices or global oil demand. But peaking of production early in the next century seems certain if the majority of oil estimates made over recent decades prove even roughly correct and if crude-oil consumption continues to rise moderately. If consumption were to stay relatively flat -- because oil prices rose sharply or alternative energy

sources were introduced -- resource depletion could be delayed by several decades. Under current and projected trends, world crude-oil production will begin to fall within years, not centuries, so decision-makers must reckon with the inevitable and begin introducing replacement energy sources as soon as possible.

The permanent global oil shortage will begin when the world's oil demand exceeds global production -- i.e. sometime between 2000-2010 AD. World oil production thereafter will continue for years at a dwindling rate. This foreseeable energy crisis will affect everyone.

...L.F. Ivanhoe, petroleum geologist and consultant.

Which sectors of the U.S. economy are most likely to be affected by rising prices and a decline in oil availability? As Figure 14 shows, transportation is the largest consumer of oil, accounting for about two thirds of the total. Motor vehicles alone make up about 53 percent of U.S. oil consumption. Jet aircraft account for another 8 percent. For all intents and purposes, transportation relies totally on oil and few viable short-run alternatives are available. Motor vehicles and air transport are thus especially vulnerable should fuel prices rise or a global fuel shortage occur.

Industry is the second largest consumer of oil, at 26 percent of the total. About one fourth of industrial oil is consumed as chemical feedstocks. With careful planning, natural gas, coal, and electricity could be used at least temporarily to meet many needs for industrial oil. Heating accounts for about half of residential and commercial oil consumption (about 4 percent of total oil use). In the short run, natural gas and electricity could substitute for some oil in building heating. But, over the long term, if the United States is to meet the overall goals of the UN Framework Convention on Climate Change, the burning of coal and natural gas would eventually also have to be cut.

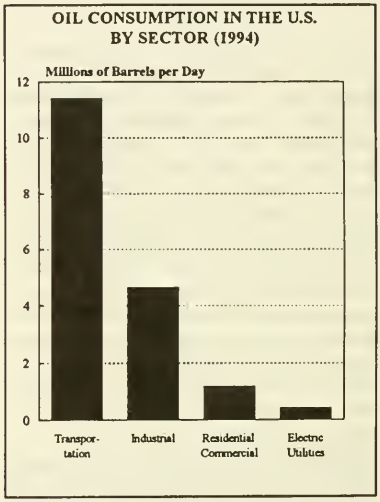

Figure 14

If the foregoing arguments are correct, alternative energy sources and technologies will have to be introduced more rapidly and on a scale larger than any experienced before. The effectiveness of

private and public investments in alternatives to oil will largely determine how efficiently we make this transition. Currently, environmental concerns, most notably air pollution, drive most government and private sector investment in alternatives to oil. But national security risks, global warming, and, especially, resource constraints provide additional reasons to develop alternatives to petroleum.

Given the importance of these issues for the economy and national security, it seems almost certain that current national investments in new technologies are too small to ensure a smooth transition to new, more sustainable energy sources and technologies. While one major U.S. car manufacturer has announced plans to introduce electric vehicles this fall into the marketplace, this program will offset only a tiny fraction of future oil demand. Nor are current levels of government investment adequate to stimulate the introduction of electric-drive vehicles and the infrastructure needed to make them viable.

Current oil prices are artificially low, too low to spur private investment in technologies that appear to have only a long-term payback. The price of oil today, especially of gasoline and diesel fuel, fails to reflect many of the social costs of producing and burning it.[36] Nowhere is this problem more stark than in ground transportation: what incentive to develop alternative energy sources do investors have when gasoline costs scarcely more than a dollar per gallon. The overall problem of low oil prices is compounded by the general failure to appreciate how little time remains before global production begins to decline and how long it will probably take to introduce new energy technologies widely.

The imminent move from oil to replacement energy sources will occur over a just a few decades, and determined efforts to make the transition as painless as possible should begin now. Perhaps most critical is the need to make energy prices -- especially those of fossil fuels -- reflect the full social costs of their production and use. In practice, this can be most efficiently achieved through pollution-, security-, and carbon (global warming) taxes. New taxes such as these could be offset by reducing taxes on income or savings or by reducing social-security or health-care taxes.

As excess global oil production capacity gradually disappears over the coming decade, oil prices can be expected to rise. When and by how much will depend on such unknowns as the growth in global oil demand, the timing and speed of production declines, and the availability of suitable substitutes. Early planning -- our best hope in mitigating potential impacts -- should entail an integrated program of price

"The oil price thus appears likely to remain at around [$20/bbl], barring disruptions to supply, until the year 2000. After this, supply will no longer be able to keep up with demand and the price will start to rise during the following decade..."

...David Woodward, General Manager of the Abu Dhabi Company for Onshore Oil Operations, 1993.

POTENTIAL IMPACTS OF ELECTRIC VEHICLES

- **Reducing Oil Consumption.** An electric car replacing a 25-mpg gasoline vehicle would displace about 13 barrels of gasoline per year, about 525 gallons. (Very little oil is used to generate electricity in the United States.) By 2010, EVs could displace upwards of 500,000 barrels of oil per day and the amount saved annually would be growing rapidly with the size of the EV fleet.

- **Reducing Greenhouse Gas Emissions.** CO_2 reductions using EVs (compared with comparable gasoline cars) depend on the fuel mix used to generate the electricity. EV use would half carbon emissions if the vehicles were powered by electricity from natural gas plants or the current U.S. national mix. CO_2 emissions would be eliminated if the EVs were recharged using renewable or nuclear electricity sources.

- **Cutting Air Pollution.** The switch to EVs in the United States (where power plant emissions are well controlled) would virtually eliminate carbon monoxide and volatile organic compound emissions and cut nitrogen oxide emissions by 60 to 70 percent.

...James J. MacKenzie, The Keys to the Car, Electric and Hydrogen Vehicles for the 21st Century, World Resources Institute, Washington, D.C. 1994.

reforms, reducing demand for oil, and expanding the supplies of alternative sources of energy, preferably non-carbon sources because of the need and international obligation to begin mitigating global climate change.

Two especially promising energy forms to replace oil in transportation are stored electricity (in batteries, flywheels, or ultracapacitors) and hydrogen. Hydrogen can be burned in combustion engines virtually pollution-free, or it can be efficiently converted (without pollution) to electricity using fuel cells.[37] Both energy forms are readily produced using such domestic renewable energy technologies as hydro dams, photovoltaic cells, or wind turbines. Also important, the use of electricity and hydrogen would reduce greenhouse gas emissions (which are rapidly growing worldwide) along with oil consumption.[38]

Confronting the transition from oil will require intensifying research on energy-storage technologies, a prerequisite for the widespread substitution of renewable energy sources for fossil fuels. As for the unique problems faced by the transportation sector, governments can accelerate the introduction of electric and hydrogen vehicles by means of fleet purchases, tax credits, and other incentives. Taken together, these measures would represent a good beginning toward mitigating the untoward economic and social impacts that we can otherwise expect as the world supply of conventional crude oil begins its inevitable decline.

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